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RECENT ADVANCES IN GEOLOGY.*

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Mr. President, and Gentlemen of the American Association for the Advancement of Science:—

THERE is an article contained in our Constitution which requires the retiring President to address the Association in general meeting; and custom has prescribed that he select for his theme some new and important discoveries in science, or some new inventions and processes in the arts.

It is in the discharge of this duty that I appear before you on this occasion, and solicit your attention for the passing hour. So vast is the domain of science, and so numerous have become its cultivators in almost every part of the world, that, even if I had the capacity, the labor of embodying the results of a single year, in a brief address, would be a mere accumulation of details devoid of that spirit which gives them value—generalization.

I shall, therefore, restrict myself to the researches which have been made in those departments of science which with me have been the subjects of special investigation; and shall

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seek to set forth what others have accomplished, rather than to advance original views.

It will be found that, throughout all time, since the earth became fitted for the habitation of organic life, that there have been great cycles of heat and cold, and that these cycles have exercised a marked influence in the modification of all terrestrial forms. To traverse the whole ground, would employ too much time; and I shall, therefore, restrict myself to the changes which barely antedate the Human Epoch.

We know that the Tertiary Age, so far, at least, as related to the northern hemisphere, was characterized by a warm and equable climate, extending even to the Polar Sea. Where now blooms the Andromeda close by banks of perpetual snow, at that time grew a luxuriant forest vegetation. McClure's sledging party gathered fragments of fossil wood, acorns, and fir cones in the interior of Banks's Land, far within the limits of the Arctic Circle. As high as latitude 70° N. in Greenland, large forests lie prostrate and encased in ice. At Disco Island, the northern verge of European settlement, the strata are full of the trunks, branches, leaves, and even the seeds and fruit-cones of trees, comprising firs, sequoias, elms, magnolias, and laurels,—a vegetation characteristic of the Miocene Period of Central Europe. Professor Heer particularly notices the *Sequoia Langsdorfii*, which is very closely allied to the *Sequoia sempervirens* of the Coast Range of California.

Spitzbergen was clothed with a forest vegetation equally luxuriant, amongst which the Swedish naturalists recognize the swamp-cypress (*Taxodium dubium*) in a fossilized state, at Bell's Sound (76° N.), and the plantain and linden in King's Bay (78° and 79° N.). The same Sequoia was observed by Sir John Richardson within the Arctic Circle west of MacKenzie River. The lignite beds of Iceland have yielded to the botanists, Steenstrup and Heer, fifteen arborescent forms identical with the Miocene plants of Europe.

In the flora of the Great Lignite Basin of Nebraska, which is referred to the Miocene age, Hayden has detected the oak, the tulip or poplar, the elm and walnut, and a true fan-palm, with a leaf-spread of twelve feet;—all, however, of extinct species. These forms he regards as characteristic of a sub-tropical climate, such as now prevails in the Gulf States. The fan-palm (*Sabal Campbellii*) is the representative of the *Sabal major* of the European Tertiaries, and the *Sabal palmetto* of our Southern States.

The *Cinnamonium*, an unquestioned tropical type, while not thus far detected in the Missouri Basin, has been found by Lesquereaux in the Cretaceous (?) beds of Bellingham Bay, on our Northwestern coast; in the Eocene of the Lower Mississippi, and in the lignite beds of Vermont.

Professor Newberry, in a review of the flora of the Cretaceous and Tertiary Ages of North America, thus remarks:—

"We have, therefore, negative evidence, though it may be reversed at an early day by further observations, that the climate of the interior of our continent, during the Tertiary Age, was somewhat warmer than during the Cretaceous Period; and that during both the same relative differences of climate prevailed between the western and central portions that exist at the present day."

The Drift Epoch was ushered in by a marked change in physical influences, by which the whole flora of the extreme northern hemisphere was so far affected that certain forms were blotted out of existence, while other forms were forced to seek, by migration, a more congenial climate, and accommodate themselves to altered conditions. In the higher regions we find a predominating growth of mosses and saxifrages, and at the southern limits of the Drift a buried vegetation of an Alpine character.

If we examine the faunæ of the two epochs—particularly the land animals which we may suppose to be peculiarly susceptible to atmospheric changes—we shall find that there

was a marked modification of forms. Dr. Leidy, in his late work on the extinct mammalian faunæ of Dakota and Nebraska, states that, of the thirty-two genera of Miocene animals, not one occurs in the Quaternary formation of North America. In comparing the Miocene and Pliocene faunæ with each other, as represented mainly by the remains from the Mauvaises Terres and the Niobrara River, scarcely a genus is common to both. "In view," he continues, "of the consecutive order and close approximation of position of the two formations and faunæ, such exclusiveness would hardly have been suspected." The greater similitude of the Miocene and Pliocene faunæ with the contemporaneous faunæ of the Old World, has led him to suggest that the North American continent was peopled, during the Tertiary Epoch, from the West. "Perhaps this latter extension," he continues, "occurred from a continent whose area now forms the bottom of the Pacific Ocean, and whose Tertiary faunæ is now represented east and west by the fossil remains of America on the one hand, and of Asia, with its peninsula, Europe, on the other."

The topographical features of the two continents and the hydrographical soundings of the two oceans, render this supposition probable. Between Ireland and Newfoundland there is a great plateau, which an elevation of the earth's crust to the extent of a few thousand feet would convert into dry land; and Behring's Straits, which now separate Asia and North America, are, at their narrowest points, but thirty miles wide, and their shallowest depth is but twenty-five fathoms.

And here the palæontologist comes to the aid of the hydrographer, and, by their joint labors, the one renders probable what the other has conjectured as possible—the former union of the two hemispheres. Zoology would indicate that such was the fact during the Pliocene Epoch, in which will probably be found the origin of those mammalian types contemporary with the elder man, and represented by

the extinct Proboscidians and Ruminants. None of these large animals could probably have passed over the straits which now divide these regions, and the close alliance in form would indicate a common origin. We infer, therefore, that the subsidence during the Drift Epoch cut off the communication between the two hemispheres, and the refrigeration which then took place, served to disperse the colossal animals, who sought by migration to lower latitudes a climate congenial to their nature.

As in Europe we find the remains of these northern types intermingled with those of an African type — the hippopotamus, which in his summer migrations strayed as far north as England; so on this continent we had, during this epoch, the great sloths, represented by the megalonyx and mylodon, whose congeners at this time exist in South America. Thus there was an inosculation, so to speak, of two distinct and contemporaneous faunæ.

It is an inquiry of the highest interest — perhaps as much so as any connected with the physical history of the past: How far has man been a witness of these stupendous changes? It is not until towards the close of the Drift Epoch, that we are enabled to detect unmistakable signs of his works, although there are not wanting proofs which would refer his origin to an earlier date — the Pliocene. So numerous and well-attested are the facts, that we must now regard him as the contemporary of many of the great mammals which have ceased to exist, and the subject of physical conditions very different from what now prevail. To account for these changes requires the lapse of a longer period of time than has heretofore been assigned to his existence upon earth.

Thus within a few years has been opened a sphere of investigation which has enlisted a large class of able observers, and their labors have thrown a flood of light upon the origin of our race. Ethnography has become aggrandized into one of the noblest of sciences. However conflicting these revelations may be to our preconceived notions, they

must not hereafter be disregarded in treating of the past and present condition of humanity. We must weigh the value of observations and press them to legitimate conclusions. The investigator at this day is not to be trammelled, in the language of Humboldt, by "an assemblage of dogmas bequeathed from one age to another"—by "a physical philosophy made up of popular prejudices."

The periods of the prehistoric man have been divided by M. Lartet, into two ages:—

1. The Stone Age, and (2) the Metal Age.

The Stone Age has been subdivided into three epochs.

1. That of the extinct animals, such as the mammoth and cave-bear.

2. That of the migrated existing animals (Reindeer Epoch).

3. That of the domesticated existing animals (Polished Stone Epoch).

The Metal Age has been divided into two epochs:

1. That of Bronze, and (2) that of Iron.

The elder man differed widely from the intellectual and much-planning man of this day. The conditions of climate greatly modified his modes of thought and physical pursuits. The northern hemisphere was just emerging from a long-continued state of glaciation. The snows which had wrapped the earth as in a mantle, were melting, and the great glaciers were reluctantly retreating within the Arctic Circle. Every depression became a lake, and every lake a sea for the reception of the accumulating waters, whose resistless force swept along mud, and sand, and shingle, and fragments of rocks. As the barriers gave way, the waters cut out channels on their route to the sea, and the terraces and ridges which border our lakes and rivers are but the monuments of their erosive action. It was a sad and desolate land, to be paralleled only in the Arctic Circle. But man was not alone. On the European Continent there was a strange assemblage of animals; the elephant, with his

compound clothing of wool and hair; the rhinoceros similarly protected; the cave-bear and cave-hyena; the tiger; and the great ox, not patient of toil as at this day, but fierce and indomitable. On this continent was the elephant of a closely-allied species; the lion and bear, and at least two species of the musk-ox, gigantic as compared to their modern congener.

In such a climate and on such a soil we can well imagine that agriculture formed no part of the occupation of the primitive man. He gathered not the kindly fruits of the earth, but was essentially a predaceous animal. The few skulls that have been recovered would indicate that he was low in the scale of intellectual organization — a small brain, a retreating forehead, and oblique jaws. In capacity he was below the Australian and New Zealander. In stature he was dwarfed, but was broad-shouldered and robust — the result, perhaps, of vigorous exertion and out-door exposure. He was carniverous, and, perhaps, a raw flesh-eater; for in the jaws which have been disinterred, the incisor-teeth are much worn — a peculiarity which has been noticed in those of the flesh-eating Esquimaux. This fact ought not to be cited to his disadvantage, for in an Arctic climate, where the animal heat is so rapidly abstracted, man requires a highly nitrogenous food. Thus we find our own countryman, Kane, when imprisoned in the ice of Rensselaer Harbor, resorting to raw walrus-meat, and rolling it as a sweet morsel under his tongue.

It cannot be gainsayed, however, that man was a cannibal. In Scotland were found the bones of children which, according to Owen, bore upon them the marks of human teeth, and the evidences produced in the Archæological Congress at Copenhagen established this fact beyond controversy. He was not destitute of skill in the art of delineation, for we have restored to us, on a slab of slate, a very good profile of the great cave-bear — the earliest instance extant of pictorial representation.

But we must accord to him one redeeming trait. That homage which, in all ages and among all nations, the living pay to the dead; those ceremonies which are observed at the hour of final separation; that care which is exerted to protect the manes from all profane intrusion; and those delicate acts, prompted by love or affection, which, we fondly hope, will smooth the passage of the parting spirit to the happy land—all these observances our rude ancestors maintained. These facts show that, deep as man may sink in barbarism, brutal as he may become in his instincts, there is still a redeeming spirit which prompts to higher aspirations, and that to him, even, there is no belief so dreary as that of utter annihilation.

Perhaps, among the existing tribes of the human race in the Arctic Highlander, as described by Sherard Osborn, we have the nearest approach to the prehistoric man: —

"Although dwarfed in stature, they are thick-set, strong-limbed, deep-chested, and base-voiced, and capable of vigorous and prolonged exertion. * * I cannot discover an instance of their ever having been seen to partake of a single herb, grass, or berry, grown on shore. Of vegetables and cereals, they have of course no conception, and I know of no other people on the earth's surface, who are thus entirely carniverous."

After the lapse of a period whose interval cannot be measured, the great animals which characterized the dawn of the Human Epoch, began to disappear, and were replaced by other forms of diminished size, but of improved type. Among these, on the European continent, were the reindeer, the musk-ox, the stag, the bison, and urus, together with the horse, not distinguishable from the existing species. The reindeer and musk-ox, which only thrive in a cold climate, not only occupied England, but wandered as far south in France as the shores of the Mediterranean and the slopes of the Pyrenees, which interposed effectual barriers to their further progress.

The reindeer must have existed in vast herds, and to the primeval man have proved the most useful of animals.

Every portion of the carcase was economized. His flesh furnished food; his skin, clothing; his sinews, thread; and his horns were fashioned into harpoons, javelins, and sockets for the reception of spearheads and hatchets.

On this continent we find the musk-ox and reindeer, identical in species with the European forms, in a fossilized state. The reindeer ranged as far south as Kentucky and New Jersey, but the existing musk-ox has not been found fossilized outside of his present limits. The Böotherium, however, which exceeded him in size, and to which he was closely allied, had a range co-extensive with the reindeer. The stag (*Cervus alces*) and the bison (*B. latifrons*), were in existence, while the horse, which is abundantly represented in the Pliocene, and is continued into the Quaternary Period, had become extinct before the discovery of America. His remains are found in Eschscholtz Bay (latitude 66° 20′ North) in connection with those of the *Elephas primigenus*, the urus, deer, and musk-ox, embedded in a deposit of clay and fine micaceous sand. The rhinoceros (*R. merianus*) appears in the Miocene of Texas, and is represented in the Pliocene of the Upper Missouri as *R. crassus*, and in the same formation in California as *R. hesperius;* but thus far the *Rhinoceros tichorhinus* so intimately associated with the great Proboscidians of Europe, has not, to my knowledge, been found in North America. In addition to these forms may be mentioned the great mastodon, which came into being subsequent to the elephant, and survived his extinction.

The fact of the existence of the mammoth or mastodon, was certainly known to the founders of the cities of Central America, for in more than one instance there is graven with elaborate care, on the walls of their structures, the form of a Proboscidian, which cannot be mistaken for one or the other of these animals; but the works on which these delineations are made, indicate a far higher order of art than was ever attained by the prehistoric man of Europe. These

delineations, I am disposed to think, are of the mastodon, and, found as they are upon the walls of stone-built palaces and temples, there is strong evidence to believe that this great Proboscidian survived almost to the Historic Period.

The men of the Reindeer Epoch made gradual advances in the industrial arts. They did not cultivate the soil, for the climate was still inhospitable. While their progenitors were content with knives flaked from flints in the form of rude fragments with cutting edges, they wrought out tools more symmetrical, but without any attempt at polishing.

They attained to a very creditable degree of artistic skill, as shown by their designs traced on tablets of ivory, and carved out of the antlers of the reindeer. We have thus represented the stag, the ibex, the horse, a reindeer couchant forming a dagger-hilt, and also the great elephant with his characteristic markings; the small oblique eye, the ponderous trunk, the recurved tusks, and the shaggy mane. The human form even is delineated. We have an ivory statuette of the female figure, and traced on a stag's horn the outline of a male figure with a caudal appendage like that which was conjectured by Lord Mondoddo, the eccentric Scotch philosopher, to appertain to the primitive man.

On this continent the evidences of the existence of man at this age, while obscure, are yet, I am disposed to believe, authentic. The human bone found in the Loess at Natchez, and the flint implements found in connection with the Missouri mastodon, may claim as high an antiquity as the oldest of the European "finds."

The discoveries in California would seem to carry back the existence of man to a remote date. As far back as 1857 Dr. C. F. Winslow sent to the Boston Natural History Society a fragment of a human cranium found in the "paydirt" in connection with the bones of the mastodon and elephant, one hundred and eighty feet below the surface of Table Mountain, California. It was in this region (Angeles, Calaveras County) that a human skull was subsequently found

by a miner named James Matson in a shaft one hundred and fifty feet deep, which passed through five beds of lava and four deposits of auriferous gravel. The statements of Professor Whitney as to the authenticity of this skull have been received with extreme distrust; but does not this earlier discovery of human remains in the same formation confirm the correctness of those statements?

Our country is yet new, and it is only recently that attention has been directed to these investigations. It is hardly to be expected that a competent observer will be present at the precise time when any relic of the past is disinterred; and there is an universal feeling of doubt and distrust as to the authenticity of all such finds. With the evidence before us that both hemispheres have been subjected to the same dynamic causes, and peopled by the same races of animals, often identical in species, is it not philosophical to infer that here we shall be able to detect the traces of man and his works, reaching back to as high an antiquity as on the European continent?

The Reindeer Epoch terminates the earliest known record in the career of man. It was signalized by a series of physical events too important to be slightly passed over. The glaciers again advanced, and again the land became refrigerated; but the cold period was not so long continued, and was less intense. To this succeeded a period of warmth, and as the glaciers dissolved under its influence, there ensued a flood which swept over the lowlands and forced the cave-dwellers to flee to the high grounds. The water in Belgium, according to Dupont, rose to the height of four hundred and fifty feet, and the calcareous mud, known as the Loess, was then deposited in the Rhine Valley. The caves were also invaded, and the "bone-earth" which forms the division between two distinct faunæ, is of the same age.

It was during this epoch that the great mammals disappeared from the earth; the elephant, the rhinoceros, the cave-bear, the cave-hyena, the tiger, and the Irish stag.

The reindeer, the musk-ox, and the elk, migrated to the north where the changed conditions of climate were more congenial to their nature.

The musk-ox has disappeared from Europe, but he survives on this continent, restricted in his range to what are known as the "Barren Grounds," lying between the Welcome and Coppermine mountains. The auroch, protected by stringent laws, still survives, while the horse, domesticated by man, has vastly multiplied. The ure-ox, living through the great catastrophe, has disappeared within historical times.

The greatly augmented thickness of the Loess on this continent, would indicate that the ice action was exerted more powerfully, and its effects are traced over a larger area; and the same destruction overtook the larger quadrupeds, extending even to the gigantic sloths, who lived in a milder climate.

From this era we may date a change in the physical conditions of our planet, so far at least as relates to the northern temperate zone. The climate became milder, and the soil yielded more bountifully those seeds and fruits which contribute to human support. Man for the first time began to show signs of progress in the industrial arts. His weapons of flint were more symmetrically fashioned, and in some instances were polished. The dog became his companion, and some of the other animals were domesticated. This was the Polished stone Epoch.

In the Bronze Epoch we trace still greater advances. Man dwelt in fixed habitations. He surrounded himself with such domestic animals as the ox, horse, pig, goat, and sheep, and retained his companionship for the dog. He cultivated wheat and barley, whose flour he kneaded into bread and baked between heated stones. Apart from berries he gathered the fruits of the pear, cherry, and plum. The discovery of the art of smelting copper, and of the additional art of hardening it by a slight admixture of tin, was an immense

stride towards civilization. Ere long followed the discovery of the art of iron-smelting, — a discovery which has done more to advance the welfare of our race than all others combined. Then it was that man, for the first time, was furnished with a weapon which enabled him to achieve a conquest over Nature, and this assertion will not appear extravagant when we reflect how intimately this metal is connected with all the industrial arts.

The Iron Epoch approaches so near the Historic Era, that, as forming a portion of geological history, the events are too insignificant to be dwelt upon.

The Mound-builders of our own country, in the scale of civilization, were intermediate between the Polished stone and the Bronze Epochs of Europe. They resided in towns, many of which have since become the sites of flourishing cities. They practiced agriculture, making use of maize as their chief cereal; but there was not on this continent a domestic animal who could aid them in their labors or contribute to their sustenance. Strange as it may seem, that while the Danish kitchen-middins and the Swiss refuse-heaps contain abundant traces of mammalian bones, thus far they have been but rarely detected in the mounds. They chipped with great skill the limestone-chert into spades, spear-heads and arrowheads. Out of porphyry or greenstone they wrought their hatchets and battle-axes, and these were often ground and polished. The same material, too, was often used in making pipes, which were carved into forms representing quadrupeds and birds, so faithful in detail that the species to which they belonged can be identified. The specular iron-ore of Missouri was elaborately wrought and polished into slung-shots or "plummets." They mined extensively the native copper of Lake Superior, which they beat, and perhaps smelted, into knives, chisels, spearheads, arrowheads and bracelets. They wove cloth with a regular warp and woof, out of a fibre as yet undetermined. They modelled clay into vases, water-coolers, and other utensils,

and ornamented them with elaborate designs, and the human face, even, is portrayed with rare fidelity; and finally, they must have maintained an intercourse with distant and widely separated portions of the continent.

Since the close of the Reindeer Epoch the changes which have taken place in the flora and fauna of Europe have been slight. We may note, however, the disappearance of the Scotch fir (*Pinus sylvestris*) from Denmark, where it is found entombed in the peat-swamps, and the introduction of the sessile oak, which in turn is becoming supplanted by the common beech. In the Baltic the oyster flourished in places from which it is now excluded, and certain other marine forms that attained a full growth, are now dwarfed. There is an instance or two of the disappearance of mammalian forms, but this may be traced to the direct agency of man. These slight changes in physical geography have modified the distribution of animals and plants, but they have not affected, in the least, their form. Whatever changes have been observed are due to domestication.

So far as relates to our own country, there are evidences in the Great Basin and on the Colorado Plateau, that at no remote day there was a much more genial climate and a soil more productive than now prevail. This is seen in the dead forests that line the mountain side; in the waterlines of the lakes and streams high above the greatest floods; deep cañons through which now course trickling streams, but which must have formed the channels of voluminous rivers; and alluvial bottoms now bare and desolate, in which are imbedded a robust vegetation.

I have, perhaps, dwelt too long upon these changes which have so essentially modified the surface of the earth, and at the same time the destinies of our race. Had an Arctic climate continued to prevail over what is now the temperate zone, man would have made no advance in civilization; life to him would have been a continued struggle for existence. It is only in a genial climate, and on a soil so generous as to

yield with moderate exertion a support, that he can cultivate his intellect; and such culture, I need hardly affirm, is at the base of all civilization.

How great the contrast between the primitive cave-dweller and the practical man of to-day, who, availing himself of the conquests of science, subjects the forces of Nature to his will; who spans with bridges, deep chasms; who stretches his iron rails over high summits; who traverses the trackless deep with unerring course; who flashes intelligence over a hemisphere. How different from the intellectual man of to-day, who weighs the earth as in a balance; who measures the distance of the sun and assays its elements; who maps the comet's path; who penetrates the deepest mysteries of the Universe. The one was almost a brute; the other is almost a god!

While these revolutions have taken place on the surface of the earth they have, at the same time, been sufficiently powerful to modify the marine fauna in the disappearance of old and the introduction of new forms to the depth of 1,500 feet; but in the profounder abysses of the ocean, age after age, the conditions of life have remained comparatively unchanged. It is only within the past year that this interesting fact — a fact which must lead to a material modification of our previously formed views — has been prominently developed.

The soundings made as far back as 1857, over the great telegraphic plateau which stretches from Valentia to Newfoundland, disclosed in all instances a fine calcareous mud which entombed countless millions of shells belonging to the family of *Rhizopods*, and some peculiar bodies which are known as *Coccoliths* and *Coccospheres*, which were found to correspond with the organic contents of the true Cretaceous Period. In 1861, among a number of living mollusca and corals found adhering to a telegraphic cable between Algiers and Sardinia, taken up for repairs, Milne-Edwards detected certain shells which were only known as Tertiary fossils. In

the same year Sars, the Swedish naturalist, described the *Rhizocrinus Lofotensis*, obtained on the Scandinavian Coast, a new and living type of Crinoidea belonging to a family characteristic of the Oolite. The soundings, prosecuted under the direction of Count de Pourtales, attached to the United States Coast Survey, between Florida and the outer edge of the Gulf Stream, have yielded important results which have been in part reported upon by de Pourtales, the elder and younger Agassiz, and Lyman.

The deep-sea dredgings prosecuted during the past year on board of her Britannic Majesty's ship Porcupine, placed at the disposal of a scientific committee, consisting of Messrs. Carpenter, Jeffrys, and Thompson, have yielded results of the highest interest. The supposition of an Azoic zone must now be abandoned. The profoundest depths of the ocean, in which the Himalayas or the Andes might be engulfed, are now believed to be inhabited, and inhabited, too, by organic forms which, since the dawn of the Cretaceous Age, have undergone no considerable modification. The littoral deposits, on the other hand show the most marked diversities in organic forms. In one sense, as declared by Dr. Carpenter, we are living in the Cretaceous Age; in another, since the close of that age we have witnessed repeated dispersions and modifications of organic forms.

Dr. Wyville Thompson, generalizing on these facts, says that there is no direct evidence that oscillations have taken place in the Northern Atlantic greater than 1,500 feet since the commencement of the Mesozoic Period, and that the great depressions in the Pacific and Atlantic oceans are due to causes that acted before that period.

"There have been," he continues, "constant minor oscillations; but the beds formed during periods of depression, but now exposed by an upheaval of this minor character, are comparatively local and shallow-water beds, as shown by the nature and richness of their fauna."

The dredgings which have been made in the fresh-water

lakes of high northern latitudes have proved of equal interest. In the Swedish lakes, Wetersee and Wenersee, have lately been discovered crustacea which, though differing from those now living in the sea, are clearly related to marine forms of a northern and even Arctic character. Thus have been found the *Mysis relicta*, whose congeners live altogether in the sea, and those resembling the species in the most northern latitudes; the *Gammarius loricatus* thus far found only in the Arctic Ocean, Baffin's Bay, Greenland, and Spitzbergen; the *Idothea entomon*, in the Arctic Ocean and the Baltic Sea; and the *Pontoporcia affinis*, still found in the Baltic, but whose related species occur in the Greenland seas. These lakes are three hundred feet above the sea-level; but these results show that at no remote day they communicated with the ocean, and were originally tenanted by a marine fauna of an Arctic type. As these waters became first brackish and then fresh, most of the forms died out during the transition, leaving in the depths a few crustacea which correspond in part to the species in the Baltic, and in part to those of the Arctic Ocean.

Within the past year Dr. Stimpson has obtained results equally interesting, from dredgings brought up from the deeper parts of Lake Michigan. The lake-level is five hundred and eighty-three feet above the ocean, and the greatest depths extend below that line. At the depth of sixty fathoms he obtained a *Mysis* which, although not specifically identical with the Swedish form, is closely allied, and its occurrence authorizes us to draw the same conclusions as to the marine character in former times of the Great Lakes, which the Swedish physicists have arrived at as to the former condition of their own.

Much discussion has been had in former years, and even in this Association, as to the nature of these lake waters during the Glacial Age. It is well known that on the borders of Lake Champlain, and at intervals along the St. Lawrence from Quebec to Kingston, and up the Ottawa, the terraces

attaining an extreme height of between four hundred and five hundred feet, contain marine remains; but when we pass over into the Great Lake-basin, these remains disappear. Hence it has been inferred that, at that time, as now, the Great Lakes were filled with fresh water; but the discoveries of Dr. Stimpson, I think, disprove the correctness of this inference; and further discoveries may show that these lakes formerly had communication, not only with the Atlantic through the St. Lawrence, but with the Arctic Ocean through Hudson Bay.

We are now led to the inquiry: What has caused these great changes of temperature, affecting the whole economy of terrestial life? Between the Arctic an Antarctic regions, there are great diversities of climate and physical conditions. The one is characterized by a vast expanse of land, and the other by a vast expanse of ocean. The one enjoys a short-lived summer in which the flowers blossom and fructify; in the other reigns unmitigated winter, and even mosses and lichens are absent. In the one the reindeer and musk-ox are hunted to the verge of the sea; in the other, animal life disappears below latitude 56 deg. Man has been able to penetrate North to 82 deg., 40 min., 30 sec., or within nearly five hundred miles of the pole; but to the south he has only reached 78 deg., 10 min., or about eight hundred and fifty miles.

There are several causes which combine to produce this result. The great continental masses which characterize the northern hemisphere, warmed by the summer sun, radiate heat into surrounding space, while the narrow expanse of land in the Antarctic circle, bathed by chilled waters, and encased in ice, acts as a refrigerator of the atmosphere. Besides, as we shall hereafter show, owing to the earth's movement, the southern summer is shorter by at least eight days, and the amount of heat received during that period by the northern hemisphere cannot but exert an appreciable influence. The Arctic region, then, enjoys a milder climate than

it would if, as in the Drift Epoch, it were submerged to the depth of at least two thousand feet. In the Great Year of astronomers, the southern pole, after having passed through its great winter solstice, is now entering upon its summer climate.

Lyell has conjectured that these phenomena are due to a different distribution of land and water, combined with a different distribution of oceanic currents; but with an expanse of land occupying almost the whole of the northern hemisphere, and with the Gulf-stream diffusing its warm breath over the western coast of Europe, and the Japan Current over the western coast of America, we find that the domain of ice and snow remains fixed; and we can conceive of no conditions, dependent upon these causes, whereby the *Cinnamonium* should again flourish at Bellingham Bay, or the *Sequoia* on the Greenland coast.

Others have inferred that these great cycles of warmth and cold may be due to the increased or diminished heat transmitted from the interior of the earth. If we adopt the theory of a cooling globe, there must have lapsed a very considerable period between the time when it passed from an incandescent state and when it became fitted for the sustenance of organic forms. Sir William Thompson, basing his observations on the well known laws of heat and conservation of energy, infers that it has only been habitable within the last one hundred millions of years. It is, then, if his estimates be true, that within this interval we are to include all the changes in the organic world — the floræ and faunæ which have successively come into being, and have successively displaced each other.

In the process of solidification the earth is supposed long ago to have arrived at that stage when the radiation from the cooling surface is no greater than that derived from the sun, and therefore, a stable temperature has been established. We would infer, then, that any violent reaction of the interior upon the external crust, would affect more sensibly the

deep-sea animals than those dwelling on the land; but the investigations which I have cited, show that while the sea-fauna has undergone slight modifications since the dawn of the Cretaceous Epoch, the land-fauna has been subjected to the most marked deviations.

May not, then, these fluctuations of temperature be due to causes which operate from the exterior? It is necessary to assume that, throughout the lapse of all time, our planet has occupied its present relation to the sun, or the solar system? Is not the recession of Sirius, which is now going on, an argument against the fixity of the siderial heavens?

We are assured that ours is not a central sun, but one in the great possession of stars which is sweeping towards the constellation Hercules; and that in the region of either there are spaces of densely-clustered stars, and other spaces which are comparatively barren. Now every star is a sun, emitting light and heat, a portion of which is transmitted to us. Our planet at this time is moving through one of those starless spaces, and therefore is not in a position to receive the full influence of such a cause. The distinguished Swiss botanist, Heer, to whom we are so largely indebted for our knowledge of the Miocene flora, has suggested that it is to this source rather than to telluric causes we are to resort to explain the varying distribution of temperature as manifested in past geological times.

Again: Have we the right to assume that, throughout all past ages, the poles of our planet have pointed in the same direction? We can conceive that, if its axis were to form with the plane of the ecliptic, the same angle which it now forms with the equatorial plane, there would ensue an entire change of climate, and consequently of organic forms. Why should the astronomer insist on the immutability of the siderial system, when to the geologist is unfolded a record of seas displaced and continents elevated; of great cycles of heat and cold; of the disappearance of old, and the appearance of new forms of organic life? Change, not constancy, is inscribed on every leaf in the volume of Nature.

I am not a believer in the doctrine of multiplied shocks. I would not, in the explanation of natural phenomena, resort to blind catastrophes. But is there not behind all, and over all, and pervading all, a great governing principle to whose operation we can refer these changes? Does it not exist in the celestial mechanism itself? To the solution of this problem the attention of several physicists has been directed.

The speculations of the French savant, Adhèmar, are not altogether to be overlooked, based as they are on the precession of the equinoxes and the movement of the apsides; a movement which, I believe, was unknown to the elder astronomers. If we compare the movement of the earth with the stars, it requires the lapse of 25,000 years to bring the equinox to correspond with the same point in space it now occupies; but the orbit itself being movable, this period is reduced to about 21,000 years. This is called the Great Year, being the measure of time before the winter solstice will again exactly coincide with the *perihelion*, and the summer solstice with the *aphelion*, and before the seasons will again harmonize with the same points of the terrestrial orbit.

The earth, at this time, approaches nearest the sun in the northern hemisphere during autumn and winter, and it is only when it recedes the farthest from the source of heat that the northern hemisphere receives the full effect of its vivifying warmth. As the earth between the vernal and autumnal equinox traverses a longer circuit than during the other half of the year, and also experiences an accelerated movement as it draws near the sun, the result is, that the northern summer is longer than the southern by about eight days; but after the lapse of ten thousand five hundred years these conditions will be reversed. It was in the year 1248, according to Adhèmar, that the Great Northern Summer culminated, since which time it has continued to decrease, and that decrease will go on until the year 11,748, when it will have attained its maximum.

This compound movement, the precession of the equinoxes and the shifting of the line of apsides, it is claimed, exerts a marked influence in the distribution of the earth's temperature. While the Great Winter prevails at the north pole, the refrigeration is so excessive that the heats of summer are insufficient to melt the snow and ice precipitated during the winter, and hence, year after year and century after century, they go on accumulating, until the circumpolar region is in a state of glaciation, and the added weight becomes sufficient to displace the centre of gravity, which would be equivalent to a subsidence at one pole and an elevation at the other. M. Adhèmar has even calculated the extent of this movement, and states that it would amount to about 5,500 feet. Now, let it be borne in mind that Professor Ramsey has shown that in Wales the submergence of the land during the Drift Epoch amounted to 2,300 feet, and our own observations show that in the northern portions of this country the glacial action proper may be traced to the height of 2,000 feet; although there were mountains which served as radiating centres, on whose flanks the Drift action may be traced much higher. These geographical points, roughly estimated, are about midway between the equator and the pole, and the extent of the subsidence would correspond very well with the calculations before referred to.

In the year 1248, the Great Winter terminated at the south pole, where for 10,500 years the accumulation of snow and ice had been going on, attended with the phenomena which we have described. "Here then," says M. Julien, an advocate of this theory, "is an irresistible force which, following the invariable law of the irregular precession of the equinoxes, must make the earth's centre of gravity periodically oscillate."

Mr. Croll, an English physicist, has elaborately discussed this question in a series of papers in the "Edinburgh New Philosophical Magazine," which have excited profound attention. With great labor he has prepared tables showing the

amount of the earth's eccentricity for the period of three millions of years, at intervals of 10,000 years for a greater portion of that time, and 50,000 years for the remainder. He infers that a glacial period occurs when the eccentricity of the earth's orbit is at a maximum, and the solstices fall when the earth is *in perihelio* and *in aphelio;* and that only one hemisphere has a glacial climate at the same time, which occurs when the winter is *in aphelio.*

In this connection I may mention the labors of our own countryman, Mr. Stockwell, who has prepared a paper, now on file in the Smithsonian Institution, embodying his own calculations as to the earth's eccentricity for the past two millions of years.

There is such an intimate connection between the several branches of science that the researches in one field often throw light upon the obscure points in another. In the solution of this difficult problem, the geologist may invoke, and I trust not unsuccessfully, the aid of the astronomer.

That a set of causes were active during the Drift Epoch, in one hemisphere, which remained dormant in the other, admits of little doubt; and the advocates of the astronomical theory, as evidences of the shifting of vast amounts of water from one pole to the other, point to the marked differences in the topographical features of the two hemispheres. In the Austral region we meet with projecting headlands and peninsula-like terminations of continents, and groups and chains of islands in the Pacific and Indian oceans extending over vast areas, which rise up like the peaks and crests of mountains. These are the evidences of a gradually engulfed hemisphere. In the Boreal region we have wide expanses of land diversified by mountains, prairies, and plains; elevated sea-beaches and river-terraces, most conspicuously displayed on the borders of the Arctic Sea; vast oceanic shoals; a marine fauna of a northern type preserved in beds of 1,400 feet, and stratified beds of gravel and sand 2,000 feet, above the ocean-level; clusters of lakes yet re-

taining their bitter waters; shallow seas once salt, but each decade becoming more brackish; vast desert tracts which up to a recent time formed the ocean bed;—all these phenomena indicate a hemisphere gradually emerging from the waters. Perhaps the physicist can discern in these great periodic oscillations, the method by which Nature perpetually renews the youth of our planet, and maintains its fertility.

Gentlemen of the American Association: — The hour which, in your courtesy, had been assigned to me, has now lapsed, and I must bring these remarks to a close. The topics which have passed under review open up spheres of thought with regard to time and space too vast to be compressed within the limits of a mere oral discourse. Asserting no ability by reason of profound research to pass authoritatively on these results, may I not inquire: Have they not disclosed new paths in the great domain of Nature, which may be profitably explored jointly by the geologist and the astronomer; and is there not a probability that there will be found to exist an intimate relation between the periodic fluctuations of temperature on our planet, and the periodic pertubations to which it is subjected as a part of the solar system? Great as have been our achievements in science during the past, we profoundly believe that new triumphs await the patient observer.

VARIATIONS IN TRILLIUM AND WISTERIA.

BY THOMAS MEEHAN.

In a recent number of the "Bulletin of the Torrey Botanical Club," of New York, Mr. J. H. Hall describes a plant of *Trillium erectum*, which he has had under his observation for several years, and which produced some years white, and other years the regular brown purple flowers. I have made

a similar observation this year in a *Wisteria sinensis*. Plants on my grounds have made an unusual second flowering. There were more blossoms in July than in April. Among them is a *snow white* variety, which has flowered annually for six years past at least. At this second flowering it took a notion to flower *blue*, — not quite as deep a blue as the regular tint of the well known kind; but still anything but the white we have always had before. It was very difficult for my gardener to believe that in some way or another "some hybridization" had not been going on. Potatoes frequently change this way in the color of the tubers, when the intelligent farmer is sure "there must have been some mixing of the pollen which in *some way* affected the circulation and changed the color." Dahlias, chrysanthemums, balsams, and many other things with parti-colored flowers, frequently have some wholly of one of the mixed colors; but all this in *some way* is supposed to be the work of art.

These natural variations I regard with much interest as teaching us that the law of evolution is not wholly through seed, and that those botanists who look for it in the embryology of the reproductive organs are not wholly on the right track.

Physiologists usually commence their treatises with "the seeds;" as if the seed was the primary element in the organization of vegetation, instead of the final result. Not that they really teach it, but this order of treating the subject gives the public mind that impression. Mr. Darwin's ideas seem to arise from some such reasoning as this. It seems hardly possible to conceive of first existences from eggs or seeds. True we see most of the changes through this medium *now;* but if we find cases in abundance (and I think we might if we looked for them) like these of *Trillium* and *Wisteria*, where changes occur independently of sexual influence, they will at least suggest another law to account for the origin of species.

THE PRIMITIVE VEGETATION OF THE EARTH.

BY J. W. DAWSON, LL. D.

TWENTY years ago scarcely anything was known, even to those engaged in the study of vegetable fossils, of a land flora older than the great coal formation. In 1860, Goeppert, in his Memoir on the plants of the Silurian, Devonian, and Lower Carboniferous, mentions only one land plant, and this of doubtful character, in the Lower Devonian. In the Middle Devonian he knew but one species; in the Upper Devonian he enumerated fifty-seven. Most of these were European, but he included also such American species as were known to him. The paper of the writer on the Land Plants of Gaspé was published in 1859, but had not reached Goeppert at the time when his memoir was written. This, with some other descriptions of American Devonian plants not in his possession, might have added ten or twelve species, some of them Lower Devonian, to his list. In the ten years from 1860 to the present time, the writer has been able to raise the Devonian flora of Eastern North America to one hundred and twenty-one species, and reckoning those of Europe at half that number, we now have at least one hundred and eighty species of land plants from the Devonian, besides a few from the Upper Silurian. We thus have presented to our view a flora older than that of the Carboniferous period, and, in many respects, distinct from it; and in connection with which many interesting geological and botanical questions arise.

Geologists are aware that in passing backward in geological time from the modern to the Palæozoic period, we lose, as dominant members of the vegetable kingdom, first, the higher phænogamous plants, whether exogenous or endogenous; and that, in the Mesozoic period, the Acrogens, or

higher cryptogams, represented by Ferns, Club-mosses, and Equiseta, share the world with the Gymnosperms, represented by the pines and Cycads, while the higher phænogams on the one hand, and lower cryptogams on the other, are excluded. Hence, the Mesozoic age has been called that of Gymnosperms, while the Palæozoic is that of Acrogens. These names are not, however, absolutely accurate, as we shall see that one of the highest forms of modern vegetation can be traced back into the Devonian; though the terms are undoubtedly useful, as indicating the prevalence of the types above mentioned, in a degree not now observed, and a corresponding rarity of those forms which constitute our prevalent modern vegetation.

It is my present object shortly to sketch the more recent facts of Devonian and Upper Silurian Botany, and to refer to a few of the general truths which they teach. The rocks called Devonian in Europe being on the horizon of the Erie division of the American geologists, which are much more fully developed than their representatives on the Eastern Continent, I shall use the term *Erian* as equivalent to Devonian, understanding by both that long and important geological age intervening between the close of the Upper Silurian and the beginning of the Carboniferous.

Just as in Europe the rocks of this period present a twofold aspect, being in some places of the character of a deposit of "Old Red Sandstone," and in others indicating deeper water, or more properly marine conditions, so in America, on a greater scale, they have two characters of development. In the great and typical *Erian* area, extending for seven hundred miles to the westward of the Apalachian chain of mountains, these rocks, sometimes attaining to a thickness of fifteen thousand feet, include extensive marine deposits; and except in their north-eastern border are not rich in fossil plants. In the smaller north-eastern area, on the other hand, lying to the eastward of the Apalachian range, they consist wholly of sandstones and shales,

and are rich in plant remains while poor in marine fossils. Hence it is the Devonian of Gaspé, of New Brunswick, and of Maine, with that of eastern New York, which have chiefly afforded the plants to be described below; and it is exclusively in these areas that we find underclays with roots, or true fossil soils. Most of the localities of fossil plants in the districts above mentioned have been visited, and their plants studied *in situ* by the writer. The Gaspé sandstones were first studied and carefully measured and mapped by Sir W. E. Logan. The Devonian beds of St. John's, New Brunswick, have been thoroughly examined and illustrated by Professor Hartt and Mr. Matthews, and those of Perry by Professor Jackson, Professor Rogers and Mr. Hitchcock. Professor Hall, of the Survey of New York, has kindly communicated to me the plants found in that State, and Professor Newberry has contributed some facts and specimens illustrative of those of Ohio.

In the Sandstone cliffs of Gaspé Bay, Sir W. E. Logan recognized in 1843 the presence of great numbers of apparent roots in some of the shales and fine sandstones. These roots had evidently penetrated the beds in a living state, so that the root-beds were true fossil soils, which, after supporting vegetation, became submerged and covered with new beds of sediment. This must have occurred again and again in the process of the formation of the four thousand feet of Gaspé sandstone. The true nature of the plants of these fossil soils I had subsequently good opportunities of investigating, and the most important results, in the discovery of the plants of my genus *Psilophyton*, are embodied in the restoration of *P. princeps*. This remarkable plant, the oldest land plant known in America, since it extends through the Upper Silurian as well as the Devonian, presents a creeping horizontal rhizome or root-stock, from the upper side of which were given off slender branching stems, sometimes bearing rudimentary leaves, and crowned when mature, with groups of gracefully nodding oval spore-

cases. The root-stocks must in many cases have matted the soils in which they grew into a dense mass of vegetable matter, and in some places they accumulated to a sufficient extent to form layers of coaly matter, one of which on the south side of Gaspé Bay is as much as three inches in thickness, and is the oldest coal known in America. More usually the root-beds consist of hardened clay or fine sandstone filled with complicated net-work or with parallel bands of rhizomes more or less flattened and in various states of preservation. In all probability these beds were originally swampy soils. From the surface of such a root-bed there arose into the air countless numbers of slender but somewhat woody stems, forming a dense mass of vegetation three or four feet in height. The stems, when young or barren, were more or less sparsely clothed with thick, short, pointed leaves, which, from the manner in which they penetrate the stone, must have been very rigid. At their extremities the stems were divided into slender branches, and these when young were curled in a crosier-like or circinate manner. When mature they bore at the ends of small branchlets pairs of oval sacs or spore-cases. The rhizomes when well preserved show minute markings, apparently indicating hairs or scales, and also round areoles with central spots, like those of Stigmaria, but not regularly arranged. These curious plants are unlike anything in the actual world. I have compared their fructification with that of the Pilulariæ or Pillworts, a comparison which has also occurred to Dr. Hooker. On the other hand, this fructification is borne in a totally different manner from that of Pilularia, and in this respect rather resembles some ferns; and the young stems by themselves would be referred without hesitation to Lycopodiaceæ. In short, Psilophyton is a generalized plant, presenting characters not combined in the modern world, and, perhaps illustrating what seems to be a general law of creation, that in the earlier periods low forms assumed characteristics subsequently confined to higher grades of being.

A second species of Psilophyton (*P. robustius*), also abundant at Gaspé, shows stouter stems than the former, more abundantly branching and with smaller leaves, often quite rudimentary. Its spore-cases are also of different form and borne in dense clusters on the sides of the stem. Masses of very slender branching filaments appear to indicate a third species (*P. elegans*) which is also found in the Devonian of St. John, New Brunswick. These species of Psilophyton occur both in the lower and middle Devonian, and, as will be mentioned in the sequel, they extend also into the Upper Silurian.

Decorticated and flattened stems of Psilophyton cannot be readily recognized, and except when their internal structure has been preserved, might be mistaken for algæ, a mistake which I believe has in some instances been made. Specimens of the barren stems (*var. ornatum*) might readily be referred to the genus *Lycopodites*.

Another genus of generalized type is that named by Haughton *Cyclostigma*. As found at Gaspé it presents slender stems with rounded scars, placed either spirally or in transverse rows, and giving origin to long rigid leaves. It had a slender axis of scalariform vessels, and fructification of the form of elongated spikes or strobiles is found with it. In many respects these plants resemble Psilophyton, and their affinities were distinctly Lycopodiaceous. Specimens from Ireland, in the Museum of the Geological Society, kindly shown to me by Mr. Etheridge, appear to show that in that country these plants attained the dimensions of trees, and had roots of the nature of Stigmaria. Mr. Carruthers has even suggested that they may be allied to *Syringodendron*, a group of Carboniferous trees connected with the *Sigillariæ*.

The genus *Lycopodites* is represented by a trailing species, bearing numerous oval strobiles (*L. Richardsoni*), a species quite close to many modern club-mosses (*L. Matthewi*), and a remarkable pinnate form (*L. Vanuxemii*),

which, though provisionally placed here, has been variously conjectured to resemble Ferns, Cycads, Algæ and Graptolites. But the most remarkable Lycopodiaceous plants are the gigantic arboreal *Lepidodendra*, plants which, while they begin in the Middle Devonian, become eminently expanded in numbers and magnitude in the Carboniferous. The common species in Eastern America (*L. Gaspianum*) was of slender and delicate form, very elegant, but probably not of large size. In the same family I would place my new genus *Leptophleum*.

The *Calamites*, afterwards so largely developed in the Carboniferous, and to be replaced by true Equiseta in the Trias, make their first appearance in a large species (*C. inornatum*) in the Lower Devonian, and represented in the middle and upper parts of the system by two other species, which extend upward into the Carboniferous. They are also represented in the Devonian of Germany and of Devonshire. The peculiar type indicated by the internal casts known as *Calamodendron* is likewise found in the Devonian.

More beautiful plants were the *Asterophyllites*, with more slender and widely branching stems, and broader leaves borne in whorls upon their branches. These plants have been confounded with leaves of Calamites, from which, however, they differ in form and nervation, and in the want of the oblique interrupted lines common to the true leaves of Calamites and to the branchlets of Equisetum. The Asterophyllites, and with them a species of *Sphenophyllum*, appear in the Middle Devonian.

No plants of the modern world are more beautiful in point of foliage than the Ferns, and of these a great number of species occur in the Middle and Upper Devonian. I must refer for details to my more full memoirs on the subject, and in the present paper shall content myself with a few general statements. Some of the generic forms of the Devonian, and perhaps a few of the species, extend into the Carboni-

ferous; others are peculiar to the Devonian; and among these forms allied to the modern Hymenophyllum and Trichomanes appear to prevail. One remarkable type, *Cyclopteris* (*Archæopteris*) *Hibernicus*, with its American allies, *C. Jacksoni*, etc., extends in the Upper Devonian over both continents, yet is wanting in the Carboniferous. Tree ferns also existed in the Devonian. Two species have been found by Dr. Newberry in Ohio, and remarkable erect trunks have been obtained by Professor Hall from Gilboa, in the State of New York. The latter are surrounded by aerial roots, and thus belong to the genus *Psaronius;* a genus which, however, must be artificial, since in modern tree ferns aerial roots often clothe the lower part of the stems while absent from the upper part. The only indication as yet of a tree fern in the Old World is the *Caulopteris Peachii*, of Salter, from the Old Red of Scotland. It is further remarkable that the ferns of the genus Archæopteris are much more large and luxuriant in Ireland than in America, and that in both regions they characterize the upper member of the system.

Of the plants of the Palæozoic world, none are more mysterious than those known to us by the name *Sigillaria*, and distinguished by the arrangement of their leaves in vertical series, on stems and branches often ribbed longitudinally, and by the possession of those remarkable roots furnished with rootlets regularly articulated and spirally arranged, the Stigmariæ. It seems evident that this group of plants included numerous species, differing from each other both in form and structure. Still, as a whole, they present very characteristic forms dissimilar from those of their contemporaries, and still more unlike anything now living. I believe that many of them were Gymnosperms, or at the least, Acrogens with stems as complicated as those of Gymnosperms. In the Carboniferous period these plants have a close connection with the occurrence of coal. Nearly every bed of this mineral has under it a "Stigmaria under-

clay," which is a fossil soil on which a forest of Sigillariæ has grown, and the remains of these trees are very abundant in the coal and the accompanying beds. Hence the Sigillariæ of the coal-period are regarded as the plants most important in the accumulation of coal. In the Devonian, as far as we yet know, they did not attain to this utility, and in the lower part of the system at least, the rhizomata of Psilophyton seem to have occupied the place afterwards held by the Stigmariæ. In connection with this it is to be remarked that the Sigillariæ of the Erian period seem to have been few, and of small dimensions in comparison with those of the coal.

Rising still higher in the vegetable kingdom, and arriving at unquestionable Gymnosperms, we find in the Devonian of Eastern America, and also, I believe, in that of Scotland and Germany, trunks which may be referred to Coniferæ. In the Middle and Upper Devonian these present the structure of modern Araucarian pines, or that modification of it belonging to the Carboniferous trees of the genus *Dadoxylon*. In the Lower Devonian we have what seems to be a simplification of the Coniferous structure, in the cylindrical wood-cells, marked only with spiral threads, found in the genus *Prototaxites*. These trees are very abundant as drift trunks in the Lower Devonian, down almost to its bottom beds, and sometimes attain to a diameter of three feet. Though of a structure so lax that it is comparable only with the youngest stems of ordinary Coniferæ, these trees must have been durable, and they are furnished both with medullary rays and rings of annual growth. Unfortunately we know nothing of their foliage or fruit.

But for one little fragment of wood we should have had no indication of the existence in the Erian of any trees of higher organization than the Conifers. This fragment, found by Professor Hall at Eighteen-mile Creek, Lake Erie, has the dotted vessels characteristic of ordinary Exogens, and unquestionably indicates a plant of the highest kind of

organization. Until confirmed by other facts this discovery may be received with doubt, but I believe it can be relied on.

Our knowledge of the flora of the Upper Silurian is at present nearly in the same state with that of the Middle and Lower Devonian ten years ago. I know in the Upper Silurian of Canada but two species of *Psilophyton*, both apparently identical with Devonian forms. In England, besides the spore-cases known by the generic name *Pachytheca*, there exists in the collections of the Geological Survey fragments of wood and bark which I believe indicate two additional species. In Germany three or four species are known in rocks of this age. All of these plants appear to be Acrogens allied to Lycopodiaceæ. That these few species constitute the whole flora of the Upper Silurian we can scarcely believe. They occur in marine formations, and were probably drifted far from the somewhat limited land-surfaces which existed in the explored parts of the Upper Silurian areas. When we obtain access to deposits of this age formed in shallows or estuaries, we may hope to find a flora of greater richness; and, judging from present indications, not dissimilar from that of the Lower Devonian.

With the exception of some remains which I believe to be of very doubtful character, the Lower Silurian has as yet afforded no remains of land plants, and in North America, at least, this is very significant, inasmuch as we have, in the Potsdam sandstone, extensive sandy flats of this period, in which we might expect to find drifted trunks of trees, if such had existed. But the search is not hopeless, and we may yet find some estuary deposit on the margin of the ancient Laurentian continent, in whose beds the plants of that old land may occur.

Lastly, for reasons stated in a paper lately published in the Proceedings of the Geological Society, I believe that the extensive deposits of graphite, which exist in the Laurentian of Canada, are of vegetable origin, and possibly in part

produced by land plants, as yet altogether unknown to us. If the Palæozoic was the age of Acrogens, the Eozoic may have been that of Anophytes and Thallophytes. Its plants may have consisted of gigantic mosses and lichens, presenting us with a phase of vegetable existence bearing the same relation to that of the Palæozoic which the latter bears to that of more modern periods. But there is another and a more startling possibility, that the Laurentian may have been the period when vegetable life culminated on our planet, and existed in its highest and grandest forms, before it was brought into subordination to the higher life of the animal. The solution of these questions belongs to the future of geology, and opens up avenues not merely for speculation, but also for practical work.

The above must be regarded as merely a sketch of the present aspect of the subject to which it relates. Details must be sought elsewhere. — *Nature*.

INDIAN STONE IMPLEMENTS.*

BY J. J. H. GREGORY.

THE stone selected for arrowheads and tomahawk points, was, as a rule, very hard in its nature, compact in structure, and fine grained, presenting a conchoidal fracture when broken. In the valley of the Connecticut these conditions were satisfied by a variety of hornstone, along the sea coast in the porphyry. In each of these localities I have found some arrowheads made of jasper, some of white granular quartz, and occasionally one from slate, but the greater proportion of these are collectively small, though it is evident

* Observations on the Stone used by the Indians within the limits of Massachusetts, in the manufacture of their implements, with some remarks on the process of manufacture, read at the Troy meeting of the American Association for the Advancement of Science.

that beauty in the material had attractions. One great source of supply for the jasper and quartz implements, was in part or wholly scattered boulders, while the porphyry came from the ledges on Marblehead Neck, and the small boulders washed up along the coast. That boulders were frequently used is proved from many half formed implements which show some of the rounded surface yet remaining. That the porphyry ledges on Marblehead Neck were an extensive source of supply, is proved by the cart loads of chippings of stone around and in the vicinity of them. That these pieces and fragments were artificially broken is proved by the many conchoidal surfaces, the fresh appearance of the surfaces, and the rough design which some of these present.

That the practice of the aborigines was to cut out but rough designs at the quarry, and work out these designs at their camping grounds, is proved by the large size of the fragments chipped off near these ledges, and the scarcity of even rough designs; while in the town of Marblehead, about a mile from the porphyry ledges on the Neck, the chippings are smaller, and the designs are nearer to completion. In the township of Marblehead I have found a multitude of implements, over a thousand in number, that were broken in every stage of the process of manufacture, while I have rarely found in the Connecticut valley fragments of unfinished implements; such as I have found are usually those of finished implements. The chippings of stone on Marblehead Neck, as I have shown, average quite large; those in the township considerably smaller, and the chippings found in the Connecticut valley are yet smaller.

The hornstones so commonly used for arrowheads and other implements there I have never found in Marblehead, and I have never found among implements of the Connecticut valley any manufactured from the porphyry of Marblehead. In one of the Reports of the Smithsonian Institution is an account of the finding of a mass of half finished imple-

ments buried in the ground; such deposits simply prove that the aborigines having cut out rough outlines of implements, at times carried these to their camping ground, and there buried them, to be finished at leisure. I exhibit specimens of a lot that I dug up in Marblehead, on the Freeto farm, about a foot below the surface; such deposits are called "Indian pockets." There were over forty pieces in the lot.

Here is one of a lot of nearly a peck, found in Hadley, Mass. The quantity in every case appeared in each instance to be about equal, apparently limited by the weight one person might conveniently carry. From a study of the breakage we learn that in making their arrowheads and tomahawk points they chipped the stone from the edge towards the centre, which, while it gave a sharp edge, left a central ridge that gave strength to the weapon. In finishing arrowheads there was a great deal of slow, careful work, which finally consisted in breaking off particles almost as fine as dust, by gentle pressure against stone. I had one arrowhead brought to me by a friend from California, made from the bottom of a glass bottle; it was very sharp and exquisitely finished. It was mostly made in his presence by an Indian squaw and nearly three days were spent in its manufacture. It can be safely stated that with the same tools no white man can make an Indian arrowhead; I am informed that even Flint Jack, skilled as he was in the business, after many years of practice, failed in his "Celts," as stone arrowheads are called in England.

From the very few arrowheads made from red jasper, found in Marblehead, I doubt whether the fine ledge of jasper located in Saugus, about five miles distant, was known to the aborigines, as the rich color of the stone, with its fine conchoidal fracture, would have been likely to have made it very popular. The material for the few arrowheads found, made of red jasper, I presume was procured from rocks of the drift deposit. The rocks used by the Indians on the coast in the manufacture of their larger implements, such as

axes, gouges, skin dressers and grain pestles, were greenstone and syenite, and in the Connecticut valley a large portion were made from trap rock. Evidently one reason why the greenstone and syenite were preferred to the porphyry was that these would take the fine finished design far more readily than porphyry. We find the difference between these rocks, illustrated by the ocean worn stones on the beach; while those from trap and greenstone, are as smooth as polished metal. Porphyry stones under the same circumstances, while they have a fine general polish, will yet oftentimes have many minute fractures below the level of the polished surface. These large implements appear to have had their forms first roughly hewn out, then to have been worked into shape by picking with sharp pointed stones after which they were sometimes polished. The axes as a rule were not polished, while the implements used in the dressing of skins were, almost uniformly. Sometimes when the natural form of the material favored, such as fragments of trap rock for pestles and for hoes, but little additional work was put upon it, and the implement was but a rough affair.

Of the large implements, as would be presumed from their character, it is rare to find any that were broken in the process of manufacture, while such as have been marred or broken, after having been manufactured, are very common. It is stated by those who have made a comparison between the large implements of this country and of Europe, that those manufactured by the aborigines of this country are hewn, picked and sometimes polished; those of Europe are simply hewn. This marked difference, if it is a fact, is not so singular as appears at first sight; the material, to a large extent, of the European implements, is flint, which, while it cannot be surpassed as a material for hewing, yet for picking and polishing, would prove very refractory, and it is probable that the same motives that led our own aborigines to avoid the porphyry, led those of Europe to be content

with simply hewing, having to deal with a still more stubborn material in their flint. The skin dressers, gouges and some other implements were made as sharp at the working edges as such stones were capable of, and this was done by rubbing them on fine grained stones. On the sea coast pieces of the finest grained greenstone were mostly used, some of which, when found, were as much worn as any modern carpenter's hone.

I have never seen among the relics on the sea coast any resembling the scalping knives of the West, or of Europe, or any whose peculiar shape suggested that it might have been used as a scalping knife. I infer from this that on the sea coast the large chippings of stone, having a sharp edge, were used as scalping knives. Among some fifteen hundred specimens of Indian implements, collected on the sea coast, I have never seen more than one, that, from its shape and size could possibly have been used as the conventional tomahawk, an axe shaped weapon to be thrown from the hand. The illustrations in some of our modern school books are more correct when the tomahawk is shown to have been a wooden club terminating in a hard woody knob, in which had been inserted a large stone point.

The form of the metallic axe was doubtless copied from the same implement used by the inhabitants of the stone age. From time to time the metallic axe has varied in form, and all the several forms of stone axes I have in my possession have been represented in some of the forms of the metallic axe, and as that of the standard axe of to-day is precisely that of one of these forms, I cannot doubt but that the stone implement supplied the model.

REVIEWS.

THE POLYPS AND CORALS OF THE NORTH PACIFIC EXPLORING EXPEDITION.*—Professor Verrill here describes, with numerous figures by Dr. Stimpson, all the Polyps and Corals collected, with notes on their colors and appearance in life, by Dr. Stimpson, which are new to science. It is an important addition not only to our knowledge of the various forms of Polyps and Corals especially, but also to their geographical and bathymetrical distribution. An excellent summary of the class of "Cnidaria," or Polyps, precedes the account of new species. The class is divided into three orders (the Madreporaria, Actinaria, and Alcyonaria,) with short definitions of the suborders into which these three groups are divided. We reproduce two of the plates from the "Proceedings" of the Essex Institute, which represent some of the more interesting forms illustrating the different groups of Polyps of the suborder Pennatulacea. Fig. 1 represents a polyp of a sea pen, *Pteromorpha expansa* Verrill; Fig. 2, the animal of *Virgularia pusilla* V.; Fig. 3, of *Veretillum Stimpsonii* V.; Fig. 4 shows the whole colony of *Kophobelemnon clavatum* V., with the polyps, or single animals, protruding from the surface. These sea pens (so called from the resemblance, in the genus Pennatula, of the whole colony to a pen) move freely about in the mud or sand at the bottom of the sea. They belong to the most highly organized polyps, the order of Alcyonaria, in which the number of tentacles of each polyp is restricted to eight. All the above named sea pens are from Hong Kong.

Of the sea fans, or Gorgonacea, the second suborder of Alcyonaria, Verrill figures (5) the coral stock, and animal (5*a*) of *Muricea Sinensis* V.; 6, the coral stock, and 6*a* the animal of *Muricea divaricata* V.; and Fig. 7, the animal of an allied coral, *Acanthogorgia coccinea* V., of which 7*a* represents a top view, with the eight tentacles outspread. All three are from Hong Kong.

Of the soft Alcyoniums, called in England Dead Men's Fingers, which do not secret a coral, our author figures the animal of *Nepthya thyrsoidea* V. (Fig. 8, 8*a*, a polyp), from the Cape of Good Hope; *Anthella lineata* Stimps., Fig. 9; 9*a*, a polyp; 9*b*, one of the tentacles much enlarged, from Hong Kong; and *Telesto ramiculosa* V. (Fig. 10, polyp-colony; 10*a*, a polyp), from the same locality. An interesting sea Anemone, *Sagartia? paguri* V., was dredged in twenty to thirty fathoms, and said by Dr. Stimpson to be always parasitic on a hermit crab, *Diogenes Edwardsii* of Stimpson. Another form, *Cancrisocia expansa* Stimpson, Fig. 9*4*,

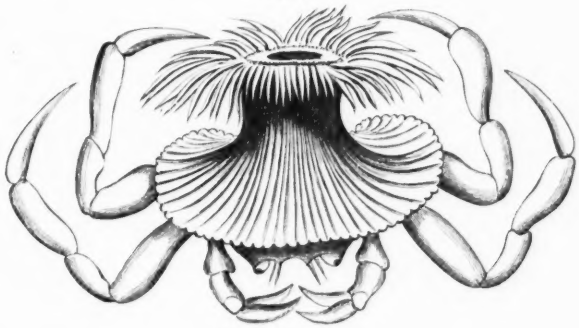
"Is the only genus of Actinidæ, except Adamsia (*A. palliata*), in which a solid secretion is formed by the basal disk. In Cancrisocia it has a concentrically striate structure, the striæ

*Synopsis of the Polyps and Corals of the North Pacific Exploring Expedition, under Commodore C. Ringgold and Capt. John Rodgers, U. S. N., from 1853 to 1856. Collected by Dr. Wm. Stimpson, Naturalist to the Expedition. By A. E. Verrill. [From the Proceedings of the Essex Institute. Vols. 4-6. Salem, Mass. 1866-1869. 8vo, pp. With 6 plates.]

being evidently lines of growth. The mode of formation seems to be this: The crab when very young, selects a very small fragment of shell or pebbles, which it holds upon its back by its posterior claws, as other species of Crabs (*Hypoconcha*) do, a valve of Pecten, or some other bivalve shell. Upon this small shelly, or stony fragment, the very young Cancrisocia finds a congenial abode; but soon growing too large for its station it enlarges its support by depositing a layer of horn-like material, secreted by the base, around its circumference, and this process is continually repeated, in proportion to its own growth, and that of the crab that carries it. In this way there is soon formed a broad thin pellicle, having its concentric elements arranged around a nucleus of stone or shell, which is usually excentric, the increase having been more rapid in front than behind. This basal secretion is held upon the back of Dorippe by its recurved posterior legs, in the same manner as the original bit of shell."

The division of Corals he raises to the rank of an order, under the term *Madreporaria*, thus making it parallel with the Alcyonaria. Among these corals numerous new forms are described and figured.

Fig. 94.



Cancrisocia expansa.

A number of species from various parts of the world are added in a supplement. The geographical list shows that most of the species are from the Seas of East India and China, the South Seas, Cape of Good Hope, and the West Coast of America.

Revue des Cours Scientifiques.* — This journal, now in its eighth year, is valuable as giving us reports of the lectures of prominent scientists in Europe, and occasionally our own country. Late numbers contain lectures by Marey on the flight of birds and insects; by Agassiz and Carpenter on deep sea dredgings; and lectures by Huxley, Claude Bernard, and the leading physicists and physiologists in France. It also contains a full report of the discussions in the recent sessions of the French Academy relative to the qualifications of Mr. Darwin to be elected a member of that body. Considering the bigotry and unscientific spirit, to say nothing of the surprisingly low grade of scientific acquirements displayed by some of the members, we should judge that if an opportunity should offer Mr. Darwin would decline the honor (*sic*) of membership.

* Edited by MM. Eug. and Yung Em. Alglave. 15 francs a year. 4to, pp. 15. Weekly. Each volume about 900 pages. Germer Balliere, 17 Rue de l'Ecole-de-Medicine, Paris.

Fig. 1.

Fig. 6.

Fig. 5.

Fig. 2.

Fig. 6*a*.

Fig. 5*a*.

Fig. 7*a*.

Fig. 3.

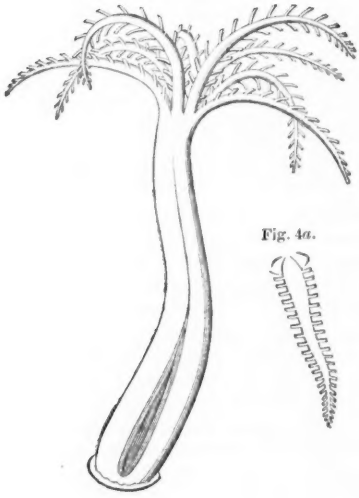
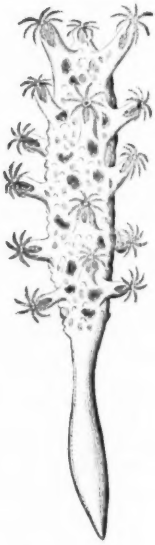


Fig. 4*a*.

Fig. 4.



NORTH PACIFIC POLYPS AND CORALS.

Fig. 9b.

Fig. 8.

Fig. 7.

Fig. 7a.

Fig. 9a.

Fig. 8a.

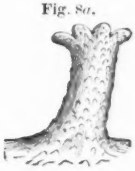


Fig. 10a.

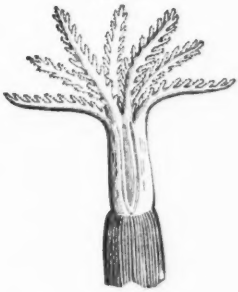


Fig. 10.

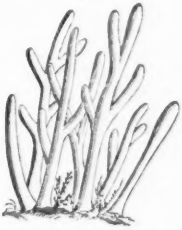
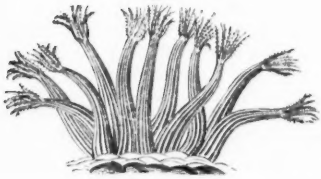


Fig. 9.



NORTH PACIFIC POLYPS AND CORALS.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

NINETEENTH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, HELD AT TROY, N. Y., AUGUST 17TH–24TH, 1870. The nineteenth meeting of the Association opened with about one hundred and fifty members. During the meeting about fifty more members entered their names, and one hundred and seventy-one new members were elected. The total number of papers entered amounted to 144, of which 30 were read by title only and 7 were excluded.

The Local Committee had secured convenient rooms for the general sessions, and those of the several sections, at the Court House, the Troy Female Seminary and the First Presbyterian Church. The local secretaries, Messrs. B. H. Hall and H. B. Nason, who, as usual, had the greater part of the Local Committee work on their hands, did all in their power to make the meeting a success, and to furnish accommodations and aid to the members in attendance.

A large and brilliant reception was given to the Association by His Honor Mayor GILBERT, on Thursday evening, and an equally brilliant one by Hon. JOHN M. FRANCIS at his residence, on Monday evening. Monday was occupied by an excursion to Saratoga and dinner at Congress Hall, at the invitation of the citizens of Troy. On Friday morning the Association steamed down the river to Albany, where they were the guests of the ALBANY INSTITUTE and were most hospitably entertained, and visited the *Dudley Observatory*, *State Cabinet*, and the large *private collection* of Professor HALL. Gathering at the *State Library* at half past four o'clock a most delightful evening was passed at a levee given by the Albany Institute, after which a fine sail up the river brought all back to Troy before midnight. "Section Q" was well carried out on Tuesday night.

During the evenings of the session many members availed themselves of the opportunities afforded for visiting the *Bessemer Steel Works*, the *Burden Iron Works*, and the *Rensselaer Iron Works;* the proprietors and superintendents of all the works being most obliging and courteous to the throngs of visitors who invaded their fiery quarters.

The address of the Retiring President, J. W. FOSTER, was delivered on Thursday evening, at the First Presbyterian Church. This address is of such general interest that we print it in full in this number.

The following were the officers of the Troy meeting:—T. STERRY HUNT,* of Montreal, *President;* JOSEPH LOVERING, of Cambridge, *Permanent Secretary;* F. W. PUTNAM,† of Salem, *General Secretary;* A. L. EL-

*In the absence of President CHAUVENET, detained by illness, Vice-President HUNT became the presiding officer of the meeting.

†Professor HARTT being absent on his expedition in Brazil, Mr. PUTNAM was elected as General Secretary.

WYN, of Philadelphia, *Treasurer*. *Standing Committee*—T. STERRY HUNT, JOSEPH LOVERING, F. W. PUTNAM, ASA GRAY, F. A. P. BARNARD, J. W. FOSTER, O. N. ROOD, JOHN TORREY, E. D. COPE, E. N. HORSFORD, J. E. HILGARD, A. WINCHELL, H. B. NASON. *Section A.—Mathematics Physics, and Chemistry*—F. A. P. BARNARD, of New York, *Permanent Chairman;* G. W. HOUGH, of Albany, *Secretary;* G. W. MAYNARD, of Troy, ELIAS LOOMIS, of New Haven, S. D. TILLMAN, of New York, *Sectional Committee*. *Subsection C of Section A.—Microscopy*—S. S. HALDEMAN, of Philadelphia, *Permanent Chairman;* R. H. WARD, of Troy, *Secretary*. *Section B.—Geology and Natural History*—ASA GRAY, of Cambridge, *Permanent Chairman*, and afterwards A. H. WORTHEN, of Springfield, Ill., and JAMES HALL, of Albany; HENRY HARTSHORNE, of Philadelphia, *Secretary*, and afterwards THEODORE GILL, of Washington; JAMES HALL, of Albany, J. G. MORRIS, of Baltimore, ALPHEUS HYATT, of Salem, *Sectional Committee*. *Subsection E of Section B.*—for one day, Tuesday, Section B. was subdivided, and THOMAS HILL, of Waltham, was elected *Chairman*, and W. H. DALL, of Washington, *Secretary*.

At the last session of the meeting it was voted to accept the invitation of the CALIFORNIA ACADEMY OF SCIENCE to hold a future meeting of the Association at San Francisco, and a committee was appointed to make arrangements for holding the meeting of 1872 in that city.

It was also voted to accept the invitation from Indianapolis, presented by the State Geologist of Indiana, E. T. COX, to hold the twentieth meeting at Indianapolis, commencing on the *Third Wednesday of August*, 1871.

The following officers were elected for the next meeting:—*President*, ASA GRAY, of Cambridge; *Vice-President*, GEORGE F. BARKER, of New Haven; *Permanent Secretary*, JOSEPH LOVERING, of Cambridge; *General Secretary*, F. W. PUTNAM, of Salem; *Treasurer*, WM. S. VAUX, of Philadelphia.

We give abstracts of several of the papers read in Section B. in this number of the NATURALIST, as well as the President's Address. In the November number we shall print others received from the authors, and shall also give extended abstracts of the several papers read in the Subsection of Microscopy, including two on the Binocular Microscope; one by President Barnard of Columbia College, and the other by Dr. Ward of Troy. We shall also then give a list of the papers read in Section B. of which we have not received abstracts, but we trust that it will be a short one, and at this time request those authors who have not yet sent us the promised abstracts to do so at once.

Prof. EDWARD S. MORSE read a paper "On the early stages of Discina." Referring to his communication last year on the early stages of Terebratulina, and the evidence then adduced of the proofs of the close relations existing between the Brachiopoda and the Polyzoa; he said that an examination of the early stages of Discina showed the same simple lophophore, sustaining a few cirri, the stomach hanging below, and other features in which a resemblance was seen.

The perivisceral wall is made up of two layers of muscular fibres which cross each other, giving it a reticulated appearance. While the young shell is oval in shape there is marked out a perfectly circular area, indicating that at the outset the embryo possesses a circular plate above and below. The muscles were very large and occupied most of the perivisceral cavity. The setæ fringing the mantle were very long, those from the anterior margin being nearly three times the length of the shell. The mantle margin, the blood lacunæ, and the bands of muscles to move the setæ were all described.

He also spoke "On the organization of Lingula and Discina." Space will only allow us to mention the new points evolved in this communication. He confirmed Carl Semper's view regarding the circulation of Lingula, viz.: that it was carried on by ciliary motion. The perivisceral cavity was in direct communication with the lacunæ of the mantle, and with the cavity of the peduncle. The circulation was voluminous and rapid; no trace of pulsation could be detected. The fluid was not blood proper, but chyle-aqueous, and distinct from this was the proper heart and blood as pointed out by Hancock.

From repeated examination of the oviducts he could state positively regarding the nature of these organs. The internal mouth was plaited and turned towards the sides, the remaining portion of the oviduct was reddish in color, and glandular, and probably performed a renal function as in similar organs among the annelids.

The sexes were separate. The coiled arms had a limited power of motion. The coils could be raised or depressed, and the axis of the coil could be at right angles to the longitudinal axis of the body or parallel to it.

The contents of the stomach were found in all the lobules of the liver, indicating that the food circulated in these hepatic prolongations, as in the annelids. Upon young Lingula a perfectly circular area could be seen near the beak of the shell; this indicated the form of the embryo shell and coincided with that of Discina. The movements of living *Lingula pyramidata*, upon which these observations were made, were described. As they live in the sand upright, their peduncle encased in a sand tube, it was interesting to notice a modification in their habits when confined in a bowl. In a short time after confinement they had built new tubes which adhered to the bottom of the bowl through their whole length. They would extend from these tubes, or withdraw when alarmed. All of the specimens he had brought from North Carolina in May were alive at this date, August 19th. They had been confined in a small bowl, with a little sand, and the water changed every two or three days. This vitality was suggestive, since Lingula had existed from the earliest geological ages to the present time.

In describing Discina he mentioned in detail, the muscular, alimentary, circulatory and reproductive systems. The oviducts were very conspicuous, and had broad trumpet shaped mouths. The so-called arteries of Hancock were traced to a ganglionic enlargement in the divaricator muscles, and were unquestionably nerves as pointed out by Owen.

Professor EDWARD S. MORSE also made a communication "On Brachiopods as a division of the Annulata." A brief abstract of these views was published in the July number of this magazine. A few new facts have been added which have been noticed under the description of Lingula.

Attention was called to the Sipunculoid worm with its anterior termination of intestine, and oviducts; its long retractor muscles, and the bilobed lophophore of its young, as described by Kowalewsky, as further proofs of the annulate character of the Brachiopods.

Dr. THOMAS HILL read a paper on "The Compass Plant." In June, 1869, Dr. Hill was coming from Omaha to Chicago, on a very dark rainy day, so dark that he could not form any estimate of the points of compass from the sunlight. At three different points on the prairies he noticed young plants of *Silphium laciniatum*, and estimated from them, while going at full speed, the course of the railway track. On reaching Chicago he procured by the kindness of the officers of the C. & N. W. road, detailed maps of the track, and found where he had estimated the bearing at 35°, 75°, and 90°, the true bearings were 31°, 78°, and 90°.

In October, 1869, being detained by an accident at Tama, he gathered seed, and this spring raised a few seedlings. Drought and insects destroyed part of them, and he could only give the history of eight plants, with fourteen leaves. Ten of these fourteen leaves showed a strong disposition, when about four inches high, to turn to the meridian; the other four showed a feeble disposition in the same direction. These ten leaves on coming up in June, had an average bearing of 42°, and the mean bearing was nearly as large. But in August, the same ten leaves showed an average bearing of only 4½°, and the mean bearing was but 2½°.

Dr. Hill refers this polarity to the sunlight, the two sides of the leaf being equally sensitive, and struggling for equal shares. He hoped in a more favorable summer to test this, and several other points which had suggested themselves, by experiments.

Professor JAMES ORTON read a paper upon the "Condor and the Humming Birds of the Equatorial Region." He remarked that probably no bird is so unfortunate in the hands of the curious and scientific as the Condor. Fifty years have elapsed since the first specimen reached Europe, yet to-day the exaggerated stories of its size and strength are repeated in many of our text books, and the very latest ornithological work leaves us in doubt as to its relation to the other vultures. No one credits the assertion of the old geographer, Marco Paulo, that the Condor can lift an elephant from the ground high enough to kill it by the fall; nor the story of the traveller, so late as 1830, who declared that a Condor of moderate size, just killed, was lying before him, a single quill feather of which was twenty paces long. Yet the statement continues to be published that the ordinary expanse of a full grown Condor, is from fifteen to twenty feet, whereas it is very doubtful if it ever exceeds or even equals twelve feet. I have a full grown male from the most celebrated locality in the Andes, and the stretch of its wings is nine feet. Humboldt

never found one to measure over nine feet; and the largest specimen which Darwin saw, was eight and one half feet from tip to tip. An old male in the Zoological Gardens of London, measures eleven feet. It is not yet settled that this greatest of unclean birds is generically distinct from the other great vultures. My own observation of the structure and habits of the Condor, incline me to think it should stand alone. Associated with the great Condor is a smaller vulture, having brown or ash-colored plumage instead of black and white, a beak wholly black instead of black at the base and white at the tip, and no caruncle. It inhabits the high altitudes, and is rather common. This was formerly thought to be a distinct species; but lately ornithologists have with one accord pronounced it the young of the Sarcoramphus gryphus — a conclusion which the speaker did not seem wholly to endorse.

As to the royal Condor, Professor Orton offered the following observations, either new or corroborative: Its usual habitation is between the altitudes of ten thousand and sixteen thousand feet. The largest seem to make their home around the volcano of Cayambi, which stands exactly on the Equator. In the rainy season they frequently descend to the coast, where they may be seen roosting on trees; on the mountains they rarely perch, but stand on the rocks. They are most commonly seen around vertical cliffs, perhaps because their nests are there, and also because cattle are likely to fall there. Flocks are never seen except around a large carcass. It is often seen singly, soaring at a great height in vast circles. Its flight is slow. It never flaps its wings in the air, but its head is always in motion as if in search of food below. Its mouth is kept open and its tail spread. To rise from the ground it must needs run for some distance; then it flaps its wings three times and soars away. A narrow pen is therefore sufficient to imprison it. In walking the wings trail on the ground and the head takes a crouching position. Though a carrion bird it breathes the purest air, spends much of its time soaring three miles above the sea. Humboldt saw one fly over Chimborazo. I have seen them sailing at one thousand feet above the crater of Pichincha. Its gormandizing power has hardly been overstated. I have known a single Condor, not of the largest size, to make way in one week with a calf, a sheep, and a dog. It prefers carrion, but will sometimes attack live sheep, deer, dogs, etc. The eyes and tongue of a carcass are the favorite parts and first devoured; next the intestines. I never heard an authenticated case of its carrying off children, nor of it attacking adults, except in defence of its eggs. In captivity it will eat everything except pork and fried or boiled meat, When full fed it is exceedingly stupid, and can be caught by the hand; but at other times it is a match for the stoutest man. It passes the greater part of the day sleeping, searching for prey in the morning and evening. It is seldom shot (though it is not invulnerable as once thought), but is generally caught in traps. The only noise it makes, is a hiss like that of a goose — the usual tracheal muscle being absent. It lays two white eggs on an inaccessible ledge. It makes no nest proper, but places a few sticks around the eggs. By no

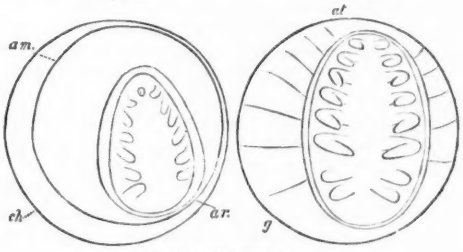
amount of bribery could I tempt an Indian to search for Condor's eggs, and Mr. Smith, who had hunted nearly twelve years in the Quito Valley, was never able to get sight of one. Incubation occupies about seven weeks, ending in April or May (in Patagonia much earlier, or about February). The young are scarcely covered with dirty white brown, and are not able to fly until nearly two years old. D'Orbigny says they take the wing in about a month and a half after being hatched, a manifest error, for they are then as downy as goslings. It is five months moulting, and while at that stage when its wings are useless, it is fed by its companion. As may be inferred the moulting time is not uniform. Though it has neither the smelling powers of the dog (as proved by Darwin), nor the bright eyes of the eagle, somehow it distinguishes a carcass afar off. He described in full the appearance of the Condor, remarking that the female is smaller than the male, an unusual circumstance in this order, the feminine eagles and hawks being larger than their mates.

Professor Orton next spoke of the Humming Bird, of the habits and economy of which our knowledge is very meagre. The relationship between the genera is not clear, and one species is no more typical than another. The only well marked divisions we can discover, are those adopted by Gould and Gray, the Phæthornithinæ and Polytminæ. The former are dull colored and frequent the dense forests. They are more numerous on the Amazon than the other group; and I know of no specimen from the Quito Valley, or from an altitude above ten thousand feet. Their nests are long, covered with lichens, lined with silk and hung over water courses. The latter comprises the vast majority of the Humming Bird, or nearly nine-tenths. They delight in sunshine, and the males generally are remarkable for their brilliant plumage. Their headquarters seem to be near New Granada; some species are confined to particular volcanoes, or an area of a few miles square. Of the four hundred and thirty known species of Humming Birds, thirty-five are found in and around the valley of Quito, thirty-two on the Pacific slope, and seventeen on the Oriental side of the Andes, making a total of eighty-four, or about one-fifth of the family within the Republic of Ecuador. If the wanton destruction of Humming Birds for mere decorative purposes, continues for the next decade, as it has during the last, several genera may become utterly extinct. This is evident when we consider that many a genus is represented by a single species, which species has a very circumscribed habitat, and multiplies slowly, producing but two eggs in a year. He noticed one fact in regard to the nests of Humming Birds, which he could not explain. Our northern hummer glues lichens all over the outside; so do a number of species in Brazil, Guiana, etc. But in the valley of Quito moss invariably is used, though lichens abound. A similar variation is seen in the nests of the chimney swallow — our species building of twigs glued together with saliva, while its Quito representative builds of mud and moss. The time of incubation at Quito is twelve days, and there is but one brood in a year.

Dr. A. S. PACKARD, Jr., presented a paper on "the Embryology of *Limulus Polyphemus*." The eggs on which the following observations were made were kindly sent me from New Jersey, by Rev. Samuel Lockwood, who has given an account of the mode of spawning, and other habits, in the AMERICAN NATURALIST. They were laid on the 16th of May, but it was not until June 3d that I was able to study them. The eggs measure .07 of an inch in diameter, and are green. In the ovary they are of various hues of pink and green just previous to being laid, the smaller ones being, as usual, white. The yolk is dense, homogeneous, and the yolk granules, or cells, are very small, and only in certain specimens, owing to the thickness and opacity of the egg-shell, could they be detected.

Not only in the eggs already laid, but in unfertilized ones taken from the ovary the yolk had shrunken slightly, leaving a clear space be-

Fig. 95. Fig. 96.



Embryo of Limulus.

tween it and the shell. Only one or two eggs were observed in process of segmentation. In one the yolk was subdivided into three masses of unequal size. In another the process of subdivision had become nearly completed.

In the next stage observed, the first indications of the embryo consisted of three minute, flattened, rounded tubercles, the two anterior placed side by side, with the third immediately behind them. The pair of tubercles probably represent the first pair of limbs, and the third, single tubercle the abdomen. Seen in outline the whole embryo is raised above the surface of the yolk, being quite distinct from it, and of a paler hue. In more advanced eggs three pairs of rudimentary limbs were observed, the most anterior pair representing the first pair of limbs (false mandibles of Savigny), being much smaller than the others. The mouth opening is situated just behind them. In a succeeding stage (Fig. 95, *ar*, areola; *am*, blastoderm skin; *ch*, chorion) the embryo forms an oval area, surrounded by a paler colored areola, which is raised into a slight ridge. This areola is destined to be the edge of the body, or line between the ventral and dorsal sides of the animal. There are six pairs of appendages, forming elongated tubercles, increasing in size from the head

backwards; the mouth is situated between the anterior pair. The whole embryo covers but about a third of that portion of the yolk in sight. At this time the inner egg membrane (blastoderm-skin?) was first detected.

The outer membrane, or chorion, is structureless; when ruptured the torn edges show that it is composed of five or six layers of a structureless membrane, varying in thickness. The inner egg membrane is free from the chorion, though it is in contact with it. Seen in profile it consists of minute cells which project out, so that the surface appears to be finely granulated. But on a vertical view it is composed of irregularly hexagonal cells, sometimes 5-sided, and rarely 4-sided, hardly two cells being alike. The walls of the cells appear double, and are either strongly waved, or have from three to five long slender projections, with the ends sometimes knobbed, directed inwards. These cells are either packed closely together, or separated by quite a wide interspace.

In a subsequent stage (Fig. 96) the oval body of the embryo has increased in size. The segments of the cephalothorax are indicated, and

Fig. 97.

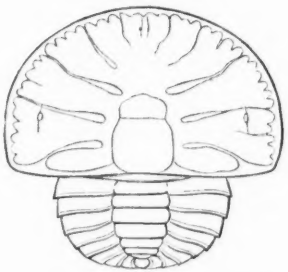
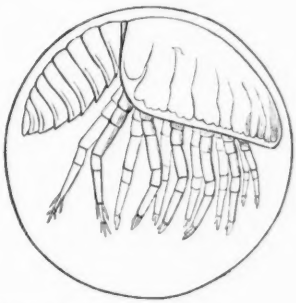


Fig. 98.



Embryo of Limulus just before hatching.

the legs have grown in length, and are doubled on themselves. But the most important change is in the small size of the rudiments of the mandibles, compared with the remaining five pairs of limbs; and the origin of two pairs of gills, forming pale oblique bands between the 6th pair of legs and the end of the abdomen, which forms a narrow semicircular area.

A later stage is signalized by the more highly developed dorsal portion of the embryo, and the increase in size of the abdomen and the appearance of nine distinct abdominal segments. The segments of the cephalothorax are now very clearly defined, as also the division between the cephalothorax and abdomen, the latter being now nearly as broad as the cephalothorax, the sides of which are not spread out as in a later stage. At this stage the egg-shell has burst, and the "amnion" increased in size several times exceeding its original bulk, and has admitted a correspond-

ing amount of sea water, in which the embryo revolves. At a little later period the embryo throws off an embryonal skin, the thin pellicle floating about in the egg.

Still later in the life of the embryo the claws are developed, an additional rudimentary gill appears, and the abdomen grows broader and larger, with the segments more distinct; the heart also appears, being a pale streak along the middle of the back extending from the front edge of the cephalothorax to the base of the abdomen.

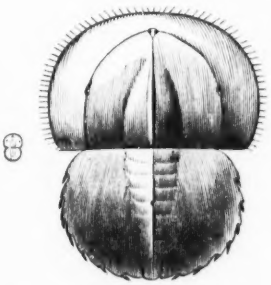
Just before hatching the cephalothorax spreads out, the whole animal becomes broad and flat, the abdomen being a little more than half as wide as the cephalothorax. The two eyes and the pair of ocelli on the front edge of the cephalothorax are distinct; the appendages to the gills appear on the two anterior pairs; the legs have increased in length, though only a rudimentary spine has appeared on the coxal joint, corresponding to the numerous teeth in after life. The trilobitic appearance of the embryo (Fig. 97 top; 98, side view) is most remarkable. It also now closely resembles the Xiphosurian genus *Bellinurus*. The cardiac, or median region is convex and prominent. The lateral regions are more distinctly marked on the abdomen than on the cephalothorax. The six segments of the cephalothorax can, with care, be distinguished, but the nine abdominal segments are most clearly demarked, and in fact the whole embryo bears a very near resemblance to certain genera of Trilobites, as *Trinucleus*, *Asaphus* and others.

In about six weeks from the time the eggs are laid the embryo hatches. It differs chiefly from the previous stage in the abdomen being much larger, scarcely less in size than the cephalothorax; in the obliteration of the segments, except where they are faintly indicated on the cardiac region of the abdomen; and the gills are much larger than before. The abdominal spine is very rudimentary, forming a lobe varying in length, but scarcely projecting beyond the edge of the abdomen. It forms the ninth segment. The young swim briskly up and down the jar, skimming about on their backs, by flapping their gills, not bending their bodies. In a succeeding moult, which occurs between three and four weeks after hatching, the abdomen becomes smaller in proportion to the cephalothorax, and the abdominal spine is prominent, being ensiform and about three times as long as broad. At this and also in the second, or succeeding moult, which occurs about four weeks after the first moult, the young Limulus doubles in size.

Conclusions. The eggs are laid in great numbers loose in the sand, the male fertilizing them after they are dropped. This is an exception to the usual mode of oviposition in Crustacea; *Squilla* and a species of *Gecarcinus* being the only exception known to me to the law that the Crustacea bear their eggs about with them. Besides the structureless, dense, irregularly laminated chorion, there is an inner egg membrane composed of rudely hexagonal cells; this membrane increases in size with the growth of the embryo, the chorion splitting and being thrown off during the

latter part of embryonic life. Unlike the Crustacea generally the primitive band is confined to a minute area, and rests on top of the yolk, as in the spiders and scorpions, and certain Crustacea, *i. e.*, *Eriphia spinifrons*, *Astacus fluviatilis*, *Palæmon adspersus*, and *Crangon maculosus*, in which there is no metamorphosis.

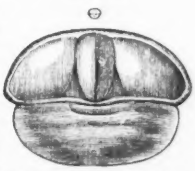
Fig. 99.



Larva of Limulus, natural size, and enlarged.

The embryo is a Nauplius; it sheds a Nauplius skin about the middle of embryonic life. This Nauplius skin corresponds in some respects to the "larval skin" of German embryologists.

Fig. 101.



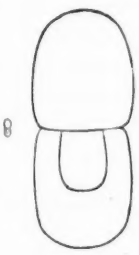
Larva of *Trinucleus ornatus*, natural size, and enlarged.

Fig. 102.

Larva of *Sao hirsuta*, natural size, and enlarged.

The recently hatched young of Limulus (Fig. 99) can scarcely be considered a Nauplius, like the larvæ of the Phyllopoda, Apus (Fig. 100 *a*) and Branchipus (Fig. 100 *b*), but is to be compared with those of the trilobites, as described and

Fig. 103.

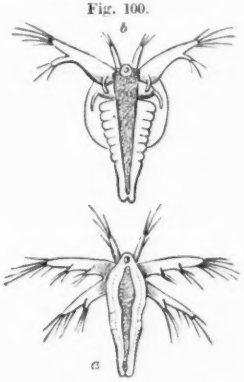


Larva of *Agnostus nudus*, nat. size, and enlarged.

Fig. 104.

Adult *Agnostus nudus*, nat. size, and enlarged.

Fig. 100.



a Larva of *Apus*.
b Larva of *Branchipus*.

figured by Barrande (Fig. 101, larva of *Trinucleus ornatus*; Fig. 102, larva of *Sao hirsuta*; Fig. 103, larva of *Agnostus nudus*) which are in *Trinucleus* and *Agnostus* born with only the cephalothorax and pygidium, the

thoracic segments being added during after life. The circular larva of *Sao hirsuta*, which has no thorax, or at least a very rudimentary thoracic region, and no pygidium, approaches nearer to the Nauplius form of the Phyllopods, though we would contend that it is not a Nauplius.

The larva passes through a slightly marked metamorphosis. It differs from the adult simply in possessing a less number of abdominal feet (gills), and in having only a very rudimentary spine. Previous to hatching it strikingly resembles *Trinucleus* and other trilobites, suggesting that the two groups should, on embryonic and structural grounds, be included in the same order, especially now that Mr. E. Billings* has demonstrated that Asaphus possessed eight pairs of five-jointed legs of uniform size. The trilobate character of the body, as shown in the prominent cardiac and lateral regions of the body, and the well marked abdominal segments of the embryo, the broad sternal groove, and the position and character of the eyes and ocelli, confirm this view. The organization and the habits of Limulus throw much light on the probable anatomy and habits of the trilobites. The correspondence in the cardiac region of the two groups shows that their heart and circulation was similar. The position of the eyes shows that the trilobites probably had long and slender optic nerves, and indicates a general similarity in the nervous system. The genital organs of the trilobites were probably very similar to those of Limulus, as they could not have united sexually, and the eggs were probably laid in the sand or mud, and impregnated by the sperm cells of the male, floating free in the water.

The muscular system of the trilobites, must have been highly organized as in Limulus, as like the latter they probably lived by burrowing in the mud and sand, using the shovel-like expanse of the cephalic shield in digging in the shallow palæozoic waters after worms and stationary soft bodied invertebrates, so that we may be warranted in supposing that the alimentary canal was constructed on the type of that of Limulus, with its large, powerful gizzard and immense liver.

Prof. GILL presented a verbal communication "On the Relations of the Orders of Mammals." He stated that in order to render at once appreciable the course which he had followed in his studies he would enunciate the guiding principles by which he had been influenced. These were five:

1st. Morphology is the only safe guide to the natural classification of organized beings; teleology or physiological adaptation the most unsafe and conducing to the most unnatural approximations.

2d. The affinities of such organisms are only determinable by the sum of their agreements in morphological characteristics, and not by the modifications of any single organ.

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*Proceedings of the Geological Society of London. Reported in "Nature." June 2, 1870. In this communication Mr. E. Billings announces the important discovery of a specimen of *Asaphus platycephalus*, showing that the animal possessed eight pairs of five-jointed feet, widely separated at their insertions by a broad sternal groove.

3d. The animals and plants of the present epoch are the derivatives with modification of antecedent forms to an unlimited extent.

4th. An arrangement of organized beings in any single series is, therefore, impossible, and the system of sequences adopted by genealogists may be applied to the sequence of the groups of natural objects.

5th. In the appreciations of the value of groups, the founder of modern taxonomy (Linnæus) must be followed, subject to such deviations as our increased knowledge of structure necessitates.

The adoption of such principles compels us to reject such systems as are based solely on modifications of the brain, those of the placenta, and those of the organs of progression, such modifications not being coincident with corresponding modifications of other organs, and therefore not the expressions of the sum of agreements in structure.

Commencing with the highest forms of mammals we have, by universal consent, the Primates. This Linnæan order, purged of the Chiroptera referred to it by its founder, includes man, the monkeys, and the lemurs, with their respective allies. It is divisible into two suborders — the Anthropoidea and the Lemuroidea.

The subjects of the next highest group are not so universally recognized, but the Feræ or Carnivora, on account of the nature of the skeleton, the development of the brain, and the organs for the perpetuation of their kind, seem to be most entitled to that rank. This order seems to embrace as suborders the ordinary gressorial Carnivora (Fissipedia) and the Pinnipedia, or Seals, Walrus, etc.

An extinct type — the Zeuglodontes — is related on the one hand to the Seals, and on the other to the toothed Cetaceans. The relation with the latter is, however, the most intimate, and it may be combined with them and the whale-bone whales into one order — the Cete — of which each form represents a suborder. The relations of the order with the Feræ is only masked by the extreme teleological modifications.

Evidently the derivatives from the same stem as the Feræ, the Insectivora, may be placed next in order. The affinity of the Chiroptera to that order is now universally recognized, notwithstanding the extreme teleological modification of its anterior members. The Ungulata are the derivatives from a common stock of a still more generalized type; the development of the brain, organs of generation, etc., indicate their comparatively high rank. Next may be placed the Glires or Rodents, and last of the Placental Mammals, the Edentata, the structure of the skeleton and especially of the skull, the organs of generation, etc., appearing to indicate, with sufficient distinctness, that thus degraded are their rank.

The relations of the subclass Didelphia, with its single order Marsupialia, and of the subclass Ornithodelphia, with another unique order Monotremata are now recognized beyond dispute.

Resuming now the consideration of the sequence by linear series, we may approach by normally specialized forms, the more generalized of each series, and thence in such cases as are necessary diverge in another

direction to the abnormally specialized. We would then have something like the series thus represented on the blackboard (some suborders being omitted), the index hands representing the respective nature and direction of the groups.

Subclass MONODELPHIA.

I.—PRIMATE SERIES.

Order PRIMATES.

Suborder ANTHROPOIDEA. Suborder LEMUROIDEA.

II.—FERAL SERIES.

Order FERÆ.

Suborder FISSIPEDIA. Suborder PINNIPEDIA.

Order CETE.

Suborder ZEUGLODONTES. Suborder ODONTOCETE. Suborder MYSTICETE.

III.—INSECTIVOROUS SERIES.

Order INSECTIVORA. *Order* CHIROPTERA.

IV.—UNGULATE SERIES.

Order UNGULATA.

Suborder ARTIODACTYLA. Suborder PERISSODACTYLA.

Order HYRACOIDEA. *Order* PROBOSCIDEA. *Order* SIRENIA.

V.—RODENT SERIES.

Order GLIRES.

Suborder SIMPLICIDENTATA. Suborder DUPLICIDENTATA.

VI.—EDENTATE SERIES.

Order BRUTA, *or* EDENTATA.

Subclass DIDELPHIA.

Order MARSUPIALIA.

Subclass ORNITHODELPHIA.

Order MONOTREMATA.

Any orders than those admitted seem problematical, and the adoption of an order Bimana for man alone — much more a subclass — seems to be opposed by every sound principle of Taxonomy. There is scarcely a proposition in biology more demonstrable than that man is the derivative from the same immediate stock as the higher anthropoid apes, and probably after the culmination to nearly the same extent as at present of the differentiation of the order into families and subordinate groups.

Professor A. WINCHELL read "Notes on some Post Tertiary Phenomena in Michigan." This paper was intended simply to make note of three classes of phenomena recently observed in Michigan.

The first note was in reference to the relics found in and beneath the numerous peat beds of the state. These beds are the sites of ancient lakelets that have been slowly filled by the accumulation of sediments. They inclose numerous remains of the mastodon and mammoth. These are sometimes found so near the surface that one could believe they had been buried within five hundred or a thousand years. For the first time, too, the remains of the gigantic extinct beaver of North America (*Castoroides Ohioensis*), have been recently found in Michigan. What is perhaps most interesting of all, is the discovery of a flint arrowhead in a

similar situation. This arrowhead was found seven feet beneath the surface in a ditch excavated in the southern part of Washtenaw county. The mastodon remains found near Tecumseh, but a few miles distant, lay but two and a half feet beneath the surface. The Adrian mastodon was buried but three feet deep.

The second note related to the occurrence of enormous beds of bog iron in the upper peninsula of Michigan, on the tributaries of the Monistique river. It occurs in a half desiccated bog covering several townships. It is of remarkable purity, and of great but unknown depth. It lies directly in the track of the projected railroad, intended to connect the North Pacific Railroad with the railroad system of Michigan. The ore can be floated down the Monistique and its tributaries, to Lake Michigan, in the immediate vicinity of an excellent harbor. This immense deposit is undoubtedly derived from the desintegration of the hæmatites and magnetites of the contiguous region on the West. The ore will possess great value for mixing with the other Lake Superior ores.

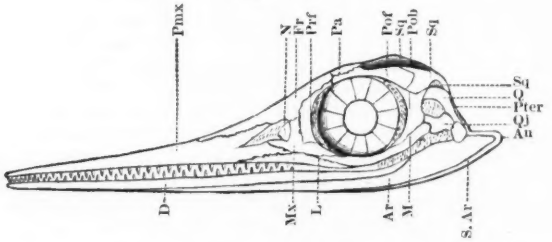
The third note was on the discovery of an ancient outlet of Lake Superior. Following the White Fish river from the head of Little Bay de Noc, we find it occupying a broad and deep valley walled in on both sides by limestone cliffs attaining an elevation of one hundred and twenty feet. The head waters of this river literally interlace with those of the Au Train river, which runs north into Lake Superior. Here is a vast valley of erosion but little elevated in any part above the present level of Lake Superior. Through this the waters of that lake must have flowed in a powerful stream in that earlier epoch when all the lakes stood from fifty to three hundred feet higher than at present. There are many evidences of glacier action along this valley. The striæ at Marquette, near the head of the valley, point North and South. In short, the evidences lead to the conviction that a vast glacier stream once traversed this valley and was probably the agency by which it was excavated. Little Bay de Noc is but the prolongation of this valley at a lower level; and, indeed, the whole basin of Green Bay seems to be but a phenomenon of erosion belonging to the epoch of the same glacier system.

Prof. E. D. Cope read a paper "On the structural Characteristics of the Cranium in the lower Vertebrata (Reptiles, Batrachia and Fishes)," giving a new systematic arrangement of the Reptilia, and determining for the first time the structures of the posterior regions of the crania in Dicynodons and Ichthyosauri.

He first pointed out the homologies of the squamosal bone, stating that it was to be recognized as the posterior half of the zygomatic arch. The zygomatic and quadratojugal are the two cranial arches which have occasionally been mistaken the one for the other, for example in the Ichthyosaurus and Sphenodon, by their describers. The squamosal was shown to be present in all reptiles except the serpents, and to be homologous, or identical, with the "temporo-mastoid" of the frog, and the preoperculum of osseous fishes, by comparison with Lepidosiren. This was proven by

the development of this element in the Dicynodons and Ichthyosaurus, where it had heretofore been erroneously determined. Thus in Ichthyosaurus it was the "supratemporal" of Owen, and besides forming the posterior half of the zygomatic arch it descended posteriorly to about opposite the middle of the posterior face of the os-quadratum. Further, it had an extensive development on the inner face of the temporal fossa reaching round nearly or quite to the postfrontal, and sending down a columella to the pterygoid. This supero-anterior portion was the parietal of Owen. The true parietal was in advance of this, and embraced the usual fontanelle, while the frontals were the nasals of Owen. The

Fig. 105.*



true nasals he recognized in small bones, one at the posterior extremity of each exterior nostril.

Turning to the Dicynodont genus Lystrosaurus, he stated that the form of the squamosal bone was very similar to that seen in Ichthyosaurus, but that it extended postero-inferiorly much further. It concealed the quadratum when viewed from behind; the latter was small and occupied a position at the inferior extremity on the intero-anterior side of the squamosal, and was attached to the pterygoid inwardly. He thought that this structure bore an analogy to that seen in the Batrachia, where the quadratum is similarly concealed. He thought the bone in the Anura, Urodela, and Dipnoi, which Huxley had suggested was the preoperculum of the Teleosts, was truly the squamosal of the higher vertebrata.

He further pointed out that Lystrosaurus possesses a columella having a superior origin quite similar to that of Ichthyosaurus. The distinctness of the proötic was pointed out as Chelonian and Lacertilian, and the presence of the parietal arches as distinct from the opisthotics was insisted on, they having been united by Owen. He then gave new deter-

* Fig. 105.—Ichthyosaurus; lateral view (from specimen from Barrow, Leicestershire).

Pmx. . Premaxillary bone.	Qj. . . . Quadratojugal.
Mx. . . Maxillary.	Q. . . . Quadrate.
N. . . . Nasal.	Pob. . . Postorbital.
Fr. . . . Frontal.	Sq. . . . Squamosal.
Prf. . . Prefrontal.	D. . . . Dentary.
Pof. . . Postfrontal.	An. . . . Angular.
Pa. . . . Parietal.	Ar. . . . Articular.
L. . . . . Lachrymal.	S. Ar. . Subarticular.
M. . . . Malar.	Pter. . Pterygoid.

minations of the opisthotic bone in the various orders of reptiles, rectifying errors which existed in modern works on comparative anatomy. He considered the suspensorium of the Ophidia to be the opisthotic and not the squamosal as given by Huxley, explaining it by reference to figures of those regions in Clidastes and Cylindrophis. In the first genus the element in question bears the squamosal on its extremity as in the Testudinata, and in the latter it forms part of the cranial walls, being supported by the exoccipital and proötic, as in Clidastes. The remarkable enlargement of the ear bones in the same groups was then described, and the homologies with the metapterygoid and symplectic of fishes and quadrate of reptiles, and of the anvil with the hyomandibular of fishes, as pointed out recently by Huxley. He pointed out a bone in Ichthyosaurus which he thought might be the hyomandibular. It is posterointerior to the quadrate, and below the opisthotic. He had not found it

Fig. 106.*

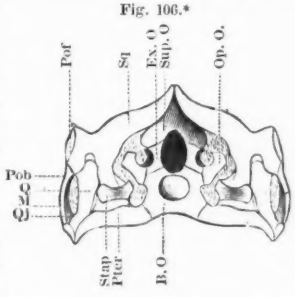
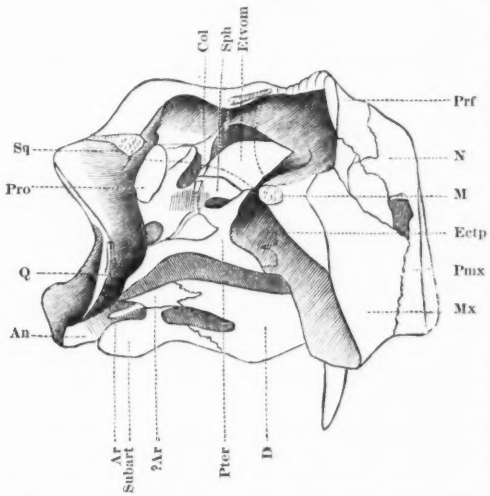


Fig. 107.†



* Fig. 106.—Ichthyosaurus; cranium; posterior view. Lettering the same as in 105 with the following additions:—

B. O. . . Basioccipital.
Ex. O. . Exoccipital.
Sup. O. Supraoccipital.
Op. O. . Opisthotic.
Stap. . . Suprastapedial or hyomandibular.

† Fig. 107.—Lystrosaurus frontosus (from Cape Colony); profile. Lettering as in 105 and 106 with the following additions:—

Etvom. . Ethmovomerine.
Sph. . . . Sphenoid.
Pro. . . . Prootic.
Pter. . . Pterygoid.
Col. . . . . Columella.
Ectp. . . . Ectopterygoid.
Subart. . Subarticular.

described. He thought that the element in Ichthyosaurus, called by authors the squamosal, was really the quadratojugal.

He next pointed out the various origins of the columella, a bone peculiar to reptiles, and designed to support the roof of the cranium. In Ichthyosaurus and Dicynodon it originated from the squamosals, in tortoises from the parietal, in crocodiles from the alisphenoid, and in lacertilia the origin could not be discovered.

He spoke of the proposition of Huxley, that some of the earlier types of reptilia in geologic time were not more generalized than those now existing. He took exception to this, and stated that the Dicynodon, among the earliest of the groups (Triassic) was the most generalized. Thus he showed it had five characters of Ichthyopterygia, three of Testudinata, two of Rhynchocephalia, three of Dinosauria, one of Lacertilia, and one of Crocodilia.

The system of Reptilia proposed was the following:

(A). Attached quadrate.

I. Parts of extremities not differentiated; ribs two headed to centrum. . . . . *Ichthyopterygia.*

II. Extremital parts differentiated:

1. Head of rib sessile on centrum tubercle to spine. . . . . *Testudinata.*
2. Capitular surface on centrum, tubercular on neural arch. . . . . *Archosauria.*
3. Capitular and tubercular united, rising to neural arch. . . . . *Synaptosauria.*

(B). Quadrate, free, mobile.

1. Ribs double headed; a quadratojugal. . . *Ornithosauria.*
2. Ribs single headed; no quadratojugal.

(a). No alisphenoid; a columella; opisthotic, all attached; feet. . . . . *Lacertilia.*

(b). Alisphenoid, no columella; opisthotic fixed, styloid; paddles. . . . . *Pythonomorpha.*

(c). Alisphenoid; no columella; opisthotic, free, mobile. . . . . *Ophidia.*

Mr. J. B. Perry read a paper on "The Supposed Elevation and Depression of the Continent during the Glacial Period." Many geologists have supposed an elevation of the northern part of the continent necessary in order to the existence of the Ice Period, and of the phenomena peculiar to it. Without resorting to a supposition of this kind wholly unauthorized by positive evidence, we may invoke certain astronomical facts which, in their combination, were perhaps sufficient to produce this great winter of the ages. Intense cold being thus occasioned by cosmical influences, the formation of an ice sheet of vast extent would naturally follow, especially if there were abundant moisture. The fact of intense igneous activity, near the close of the Tertiary Period, suggests the occurrence of immense evaporation, and thus a source of aqueous supply. An ice-

sheet might thus be formed. Great cold prevailing on its northern limits and serving as a barrier to its motion in that direction, there being at the same time a partial melting of its southern face, the waters from the wasting snows on its surface percolating the icy mass, there also being contractions and expansions consequent upon alternations in the temperature; all these being connected with the gravitating force of a mass from five thousand to ten thousand feet in thickness, motion to the south would inevitably result, even on a horizontal surface, and much more if there were a southward inclination of the country. Under these circumstances we have an instrumentality fully able to plane, smooth, and striate the rocky floor of the continent as it now appears, and thus to account for the debris almost everywhere met with in great abundance.

But if there were no elevation of the country, how are we to explain the occurrence of pot-holes in places apparently never traversed by torrents; the formation of fiords; the existence of sub-marine river-channels, as those extending from the mouths of the Hudson and the Connecticut; or the fact of sub-aërial deposits, as mud-flats, now found beneath the level of the ocean? It is well known that, when glaciers meet with obstructions, breaks (known as *moulins*) occur in them; that the snows melting on the surface of the ice-mass, streams are formed, which flow into these breaks, and thus become torrents and cascades, which wear pot-holes in every respect similar to those requiring explanation. Again it should be remembered that such an ice-sheet moving seaward must, in displacing the waters along the shallow margin of the ocean, do its legitimate work of erosion, and that thus old depressions would be deepened, while new valleys and fiords would be formed, as well as sub-marine river-channels, which remain to this day. Accordingly all this erosion might readily take place without an elevation, even if the sea were at its present height. But this leads us to ask, whence came the immense ice-sheet; undoubtedly for the most part from the ocean. Thus its waters must have undergone a great depression, perhaps one of several hundred feet; and this enables us to account for the mud-flats and other like deposits, which were probably laid down when the ocean was at a lower level than it is to-day.

It has been, moreover, thought necessary to suppose that a depression of the continent finally followed its conjectured elevation. The land having been lifted up, it must be got down again, in order that there might be a return of warmth, and things be as we now find them. Now marine organic remains seem to attest a depression, in some places, of about five hundred feet. But so slight a submergence of the land, there being upon it an ice-sheet thousands of feet in thickness, could not cause a return of warmth, while the cosmical agencies already referred to are abundantly sufficient for the production of such an effect. This summer of the ages thus coming on, the ice-sheet as gradually melting must retreat northward. And the waning of the glacial mass would be accompanied by results which require an explanation.

The ice thawing, the detrital matter which lay beneath it, and is now known as typical drift, would be laid bare and left substantially as we find it. In this view a resort to a depression of five thousand or six thousand feet, and to iceberg agency, is unnecessary. Indeed, Arctic icebergs could not furnish the material of New England typical drift, since it is for the most part of local origin; while bergs of ice from the White Mountains could not have supplied it, for it is a continuous sheet, having a uniform glaciated character, spreading over vast areas lying far to the north of these mountains. So icebergs could not have deposited it, because, as they slowly wasted, the particles of matter must have been scattered by the flux and reflux of the tides, and thus to a large extent stratified. Again, from the southern border of the wasting ice-sheet, floods of water would flow, working over and remodeling portions of the detrital masses, bearing some of the finer material southward, and laying down those deposits known as modified drift. These constitute in part the terrace formations, which usually slope with the rivers along which they occur. In some instances there were barriers obstructing the waters; thus were formed ponds and lakes, in which deposition took place in more nearly horizontal layers. Finally from the wasting of the ice-sheet the surface of the ocean must be elevated, its waters spread over the lower levels of the still slightly depressed lands, laying down beds containing marine organic remains, which to-day bear witness of a partial depression. In due time, after the disappearance of the ice-sheet, the continent would resume its normal elevation, the brackish waters of the ocean be excluded, and all things come gradually to take the position in which we now find them.

In conclusion it may be asked whether the explanation suggested be not in consistency with the facts, and thus whether we ought not to accept it, rather than arbitrarily to resort to the assumption of a vast continental elevation and depression, which if not disproved, is at least unsupported by positive evidence.

Mr. DALL described three new generic forms of Brachiopoda, principally from the collections of the United States Exploring Expedition. Two of these belonged to the group of articulated Brachiopods, while the third was that animal, which, under the name of Lingula, had just been described by Mr. Morse. Mr. Dall then spoke of several special points of structure, especially the peduncle of Lingula, demonstrating its construction to be analogous to that of the siphons of bivalve mollusks, such as the common clam, *Mya arenaria*. He then described the bristles of Lingula, showing that they were quite different in construction from those of the worms, and also that the Chitons were (in some genera) provided with true follicular setæ, proceeding from the mantle. Hence these characters cannot be held to afford satisfactory evidences of affinities with Annelids. Mr. Dall then proceeded to discuss the theory of Mr. Morse, that the Brachiopods were a subdivision of the Annelids. Mr. Dall took the opposite view, and, while admitting all the facts

brought forward by Mr. Morse, and fully appreciating the careful and thorough nature of his researches, contended on the other hand that these facts were susceptible of quite another interpretation.

Mr. Dall then went on to take up, one by one, the circulatory, nervous, muscular, and digestive systems of the Brachiopods, and to compare each with the same organs in the Annelids and the Mollusks, and came to the conclusion that the weight of structural characters was essentially of a Molluscan nature. The Mollusks were an individualized type, while the Annelids, and even most of the Articulates were typified by their repetition of similar organs. No such repetition obtains among the Brachiopods. Mr. Dall was of the opinion that the Molluscoidea should rank as one of two great primary divisions of the Mollusca — one, the true Mollusks, typified by the Gasteropoda, and second the Molluscoidea, typified by the Brachiopoda. The second division would include the Polyzoa, Tunicata, and Brachiopoda, and Mr. Dall was of the opinion that these groups were essentially related to one another, and cannot be separated without violence to their affinities.

In reply to Mr. Dall's communication and objections advanced, Prof. Morse replied in brief as the time for adjournment had passed. He would only take a few moments in correcting some points in which Mr. Dall had evidently misunderstood the general articulate characters claimed for the Brachiopods. In this respect his demonstration of the striated muscular fibre in the Brachiopods accorded well with the views advanced, inasmuch as striated muscular fibre is a great characteristic of the crustacea, and does not occur in the mollusks. Mr. Dall did not know of any tubicolous worms having a blind intestine. Professor Morse referred him to certain worms in the inferior groups. His views on Chiton were rather strange, seeing that Chiton presented articulated characters in its development, the presence of a dorsal vessel, the terminal opening of intestine, and the forward opening of oviducts. As to a comparison between the peduncle of Lingula and the syphonal tubes of Mya, the relations were so different that they could not enter the discussion whatever. The related points, as indicated by the structure of the oviducts, were not properly appreciated by Mr. Dall. He referred to the figure still kept upon the board as presenting all the points involved, and would demand a molluscan character in the Brachiopods. He then carried out the points raised by Mr. Dall, by citing other mollusks, with strong articulated features, which Mr. Dall had overlooked.

Mr. Thomas Meehan read a paper "On the Laws of Fasciation, and its relation to Sex in Plants." He said that in trees, branches often came out in thick masses, which botanists called "fasciations," and the people "Crow's Nests." An over supply of nutrition was the received theory of their origin. He believed the reverse to be the fact. In proof of this he stated that the shoots forming the bunch of branches never grew as vigorously as the others, the leaves were of a paler hue, and in evergreens, the leaves were deciduous. Many of the shoots died in severe winters.

All these results were due to imperfect nutrition, the effect of which was a low state of vitality. That weakness produced the fascicle was also proved on the theory propounded in his Chicago paper, "Adnation in Coniferæ." There it was seen that distichous leaves in coniferæ came only with increased vigor of growth. The leaves were less free from cohesion with the stem in proportion as vitality was low. Here were the same facts. The leaves on the fascicle of the Balsam Fir were of the same nature as the weak leaves described in the paper referred to. Mr. Meehan had also shown, at the Salem meeting, that sex was influenced by the condition of vitality. The male sex followed from a loss of vigor. Here the same law followed fasciation. The fasciated bunches in the Blackberry, produced foliaceous calyx sepals; and where the bunches were of numerous branchlets, an increase of petals followed. In a variety known as Willson's Early, the number of branchlets in the bunch was often greater than in other instances. Then the female organs were nearly all aborted, and the flowers were completely *double*. Thus proving at once that weakness was unfavorable to the female sex, and proportionately favorable to fasciation. The conclusion reached, was that fasciated branches, or "Crow's Nests," are the consequence of impaired nutrition or vitality.

Mr. THOMAS MEEHAN read a paper "On objections to Darwin's Theory of Fertilization through Insect Agency." He said that the discoveries of Darwin had disclosed wonderful apparent arrangements for fertilization through insect agency; but occasionally instances were found where with the most perfect facilities insects seemed to make no use of them. These had been considered as objections to a full acceptance of Mr. Darwin's theories. The Salvia was an instance. The lower division of the anther acted as a petaloid lever, closing the throat of the corolla tube, which *ought* to throw the pollen on the back of the bee when it entered for the honey. The principle was perfect. *But no insect is seen to enter.* On the other hand the Humble Bee, "without which," Darwin says, "some species would die out in England," bores a hole on the outside, through which it gets the honey. The Humble Bee thus seems to avoid its duty here. A similar state of things exists in the Petunia of our gardens. The humble bee extracts the honey by making a slit in the tube, and avoids interference with the pollen. But Mr. Meehan found that these flowers are the favorite resort of Sphinx's and other night moths, which do extract the honey from the mouth of the tube, and thus cross fertilize. It would thus seem that plants not only do as a rule prefer fertilization by insect agency, but probably some classes of flowers have their preferences for certain classes of insects. In the case of Salvia, probably some insects peculiar to their native countries, fertilize them; especially is this probable, as in cultivation the Salvia produces very little seed.